NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

THE EFFECT OF AVIATION SELECTION TEST BATTERY WAIVERS ON MARINE STUDENT-AVIATOR ATTRITION

by

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March 2009

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** March 2009	**3. REPORT TYPE AND DATES COVERED** Master's Thesis

4. TITLE AND SUBTITLE: The Effect of Aviation Selection Test Battery Waivers on Marine Student-Aviator Attrition	**5. FUNDING NUMBERS**
6. AUTHOR(S): Charles J. Koch	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.	**12b. DISTRIBUTION CODE**

13. ABSTRACT (maximum 200 words)

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14. SUBJECT TERMS Aviation Selection Test Battery, Minimum Score Waivers, Flight School Attrition, Marine Corps Student-Aviators	**15. NUMBER OF PAGES** 96
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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THE EFFECT OF AVIATION SELECTION TEST BATTERY WAIVERS ON MARINE STUDENT-AVIATOR ATTRITION

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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LIST OF ABBREVIATIONS AND ACRONYMS

ACT	Standardized College Admission Examination
AFQT	Armed Forces Qualification Test
ANI	Aviation and Nautical Information Test
API	Aviation Preflight Indoctrination
AQR	Academic Qualifications Rating
ASM	Manpower & Support Branch
ASTB	Aviation Selection Test Battery
CMC	Commandant of the Marine Corps
CNATRA	Naval Air Training Command
eATJ	Electronic Aviation Training Jacket
ECP	Enlisted Commissioning Program
FOFAR	Flight Officer Flight Aptitude Rating
FRS	Fleet Replacement Squadron
GED	General Education Development Test
HQMC	Headquarters, United States Marine Corps
IFS	Introductory Flight Screening
LPM	Linear Probability Model
MCP	Meritorious Commissioning Program
MCRC	Marine Corps Recruiting Command
MECEP	Marine Enlisted Commissioning Education Program
MPPM	Military Personnel Procurement Manual
M&RA	Manpower & Reserve Affairs
NAMI	Naval Aerospace Medical Institute
NAS	Naval Air Station
NAVAVSCOLSCOM	Naval Aviation Schools Command
NFO	Naval Flight Officer
NOMI	Naval Operational Medicine Institute
NROTC	Naval Reserve Officer Training Corps
OAR	Officer Aptitude Rating
OCC	Officer Candidate Course
OCS	Officer Candidate School
PFAR	Pilot Flight Aptitude Rating
PLC	Platoon Leaders Class
SAT	SAT Reasoning Test
SSN	Social Security Number
TFDW	Total Force Data Warehouse
TBS	The Basic School
USNA	United States Naval Academy
WSO	Weapons Systems Officer

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ACKNOWLEDGMENTS

I would like to thank my advisors, Dr. Sam Buttrey and Dr. Mark Eitelberg, for their professionalism, patience, and invaluable guidance. I would also like to thank Major Tracy Perry from Marine Corps Recruiting Command, Isaac Ostlund from Science Applications International Corporation, Lieutenant Commander Henry Phillips from the Naval Aerospace Medical Institute, and Lieutenant Chris Foster from the Naval Air Training Command for their tremendous support in providing the data for this research. Finally, yet most importantly, I would like to thank my family for their love, encouragement, and endless support. Above all, I would never have been able to complete my studies without the support of my wife, Jennifer.

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I. INTRODUCTION

The strength of any successful organization is its people. It is the reason that the Marine Corps, like any other large military or civilian organization, commits considerable resources to select the best-qualified people to fill its ranks. These selection decisions are driven by demanding requirements and important considering that personnel replacement costs in the Marine Corps are arguably higher than in the civilian labor market. This is particularly true in occupational specialties that require a considerable investment in human capital, such as linguistics, communications, electronics, and aviation.[1]

For these reasons, all selection decisions in the Marine Corps are guided by strict standards. In many cases, the standards are simple and easily measured, such as age, height and weight, and education. In other cases, aptitude tests are used and candidates must achieve certain minimum scores for selection. For example, all Marine enlistees must attain a passing score on the Armed Forces Qualification Test (AFQT), a test that is also used to determine an individual's eligibility for assignment to various occupational specialties. Likewise, the Defense Language Aptitude Battery is used to screen candidates for foreign-language training. In the case of aviator training, all Marine Corps pilot and Naval Flight Officer (NFO) candidates must take the Aviation Selection Test Battery (ASTB) and achieve minimum or "cutoff" scores set by Headquarters, U.S. Marine Corps (HQMC).

The size of the population eligible for testing, the organization's desired selection ratio, and testing and selection costs all influence the decision to establish cutoff scores on a selection test. While low cutoff scores can produce a higher selection rate and reduce testing and selection costs, they can result in higher attrition. Assuming a test is a valid predictor of successful performance,

[1] The Chief of Naval Air Training in Corpus Christi, Texas calculated the actual cost per student pilot (strike) and Naval Flight Officer (strike) in 2007 to be $881,052.30 and $298,310.58 respectively.

persons with lower test scores can be expected, on average, to underperform and to disenroll or “attrite” at higher rates than those with higher scores. Similarly, while high cutoff scores will likely reduce attrition costs, achieving a desired selection ratio can be much more difficult and costly for an organization.

The Marine Corps’ current minimum score policy for the ASTB is 4/6. More specifically, Marine aviator candidates must achieve an Academic Qualifications Rating of at least four and a Flight Aptitude Rating of at least six out of nine possible points. The Marine Corps also grants test-score waivers for a limited percentage of aviator accessions each fiscal year. While this policy has changed very little since 1989, there is no historical documentation available to support it and no formal research has been conducted to determine the effect on flight school attrition of granting ASTB waivers to Marine student-aviators. Such a study is of great interest to policy makers for obvious reasons. If Marine student aviators who are granted an ASTB waiver are just as likely to succeed in training as are those without a waiver, the Marine Corps may be unnecessarily excluding otherwise qualified aviator candidates from training. Conversely, if persons with a waiver are more likely to attrite from training, the Marine Corps may be unnecessarily incurring attrition and additional training costs.

A. RESEARCH OBJECTIVES

This study has two objectives. The first objective is to determine whether Marine Corps student-pilots and NFOs with an ASTB minimum score waiver are significantly more likely to attrite from flight training for performance or motivation reasons. The second objective is to determine the effect on flight school attrition for performance or motivation reasons of changing the Marine Corps' current ASTB minimum score waiver policy to allow more than ten percent of aviator candidates to enroll annually with a test-score waiver.

B. BENEFITS OF STUDY

This study provides Marine Corps Recruiting Command (MCRC) and Aviation Department, HQMC with the first formal statistical analysis of the effect of ASTB minimum score waivers on flight school attrition for Marine student-aviators. This analysis also provides policy stakeholders with justification to support existing policy and may serve as the basis for future policy changes.

C. SCOPE AND LIMITATIONS

This study examines the effect of ASTB minimum score waivers on flight school attrition for Marine Corps student-aviators who began Aviation Preflight Indoctrination (API) between 1 January 1999 and 30 September 2006. Analysis was limited to this period for two important reasons. First, the Naval Air Training Command (CNATRA) in Corpus Christi, Texas had little confidence in the accuracy of student training data prior to January 1999. Second, considering that aviation training can last more than two years, data were limited for those aviator candidates who accessed after the end of fiscal year 2006.

In addition, this research does not consider aviator attrition during Introductory Flight Screening (IFS), a preliminary flight-training course required prior to API. Analysis of the IFS program data available for Marine students who accessed during or after 2002, revealed significantly fewer observations for each fiscal year than in the more complete data available from other sources. Additionally, the IFS dataset did not include ASTB scores, and its unique identifier could not be used to merge the program information with the demographic data needed for this research.

Furthermore, the examination of the effect of all possible ASTB waiver score combinations was limited. As explained in Chapter III, the frequency of some test-score combinations in the dataset was such that too few observations were available for analysis.

Finally, this study does not offer a complete analysis of the Marine Corps' ASTB minimum scores policy. A complete policy analysis would require examining other important factors, such as aviator recruiting costs, the numerous direct and indirect aviation-training costs, and the effects of minimum scores on minorities. An overarching analysis of such magnitude would likely require a separate thesis. Of note, Dean (1996) examined the effect of the Marine Corps' ASTB cutoff scores on racial and ethnic minorities and concluded that while higher cutoff scores improved overall student-aviator performance, minority candidates were deselected at a disproportionately higher rate (p. 35).

D. ORGANIZATION OF STUDY

This remainder of this study is organized into four chapters. Chapter II provides background information and a review of literature relevant to this research. Specifically, the discussion includes the Marine Corps' aviation accession sources and policy, the ASTB, Naval aviation-training pipeline, and flight school attrition. Chapter III provides a description of the data used in this study and a preliminary analysis of the relationship between ASTB waivers, flight school attrition, and various demographic factors. Chapter IV presents the statistical models, simulation methodology used, and the results of this study. Chapter V includes a summary, conclusions, and recommendations.

II. BACKGROUND AND LITERATURE REVIEW

This chapter provides the reader with background information and a review of literature relevant to this research. First, the various officer procurement sources from which the Marine Corps accesses aviators are introduced along with the basic eligibility requirements for service as a Marine aviator. Second, the Aviation Selection Test Battery (ASTB) and the Marine Corps' minimum scores policy are reviewed. Third, discussions of the Naval aviation training pipeline and flight school attrition reasons are provided. The chapter concludes with a review of prior studies relevant to this research.

A. MARINE CORPS AVIATION ACCESSIONS

The Deputy Commandant for Manpower and Reserve Affairs (M&RA) is responsible to the Commandant of the Marine Corps (CMC) for all personnel accession plans and policies. The Commanding General, Marine Corps Recruiting Command (MCRC) is responsible to CMC for achieving the Corps' accession mission and for managing all enlisted and officer accession programs. The Corps' guiding instruction for the procurement of military personnel is the Military Personnel Procurement Manual (MPPM). The manual consists of three volumes. Volume 1 provides basic policy, administrative, fiscal, and manpower systems management guidance (HQMC, 1989). Volume 2 pertains to enlisted personnel. Volume 3 governs the procurement of officers and accessions from various officer candidate programs into the Marine Corps' aviation, law, and ground occupational specialties. Provided below are an overview of the sources from which the Marine Corps enrolls aviators and the basic eligibility requirements for service as a Marine aviator.

1. Aviation Accession Sources

In addition to staffing its ground and law occupational specialties, the Marine Corps recruits hundreds of aviators each year. For fiscal years 2008 and

2009 alone, the Marine Corps' initial aviation accession goals required 420 pilots and 35 Naval Flight Officers (HQMC, M&RA, 2007). To meet these requirements, the Marine Corps enrolls aviators from its four primary commissioning sources, the Platoon Leaders Class (PLC), Officer Candidate Course (OCC), Naval Reserve Officer Training Corps (NROTC), and the United States Naval Academy (USNA). The Corps also enrolls aviators from various enlisted-to-officer commissioning programs. The approximate percentages of officers that the Marine Corps accesses from these programs each year are provided in Figure 1. The PLC program typically provides the greatest number of Marine Officer accessions (35%) and therefore provides the largest population of officers from which to select aviator candidates. The Marine Corps' various enlisted-to-officer commissioning programs provide the smallest percentage of accessions (12%).

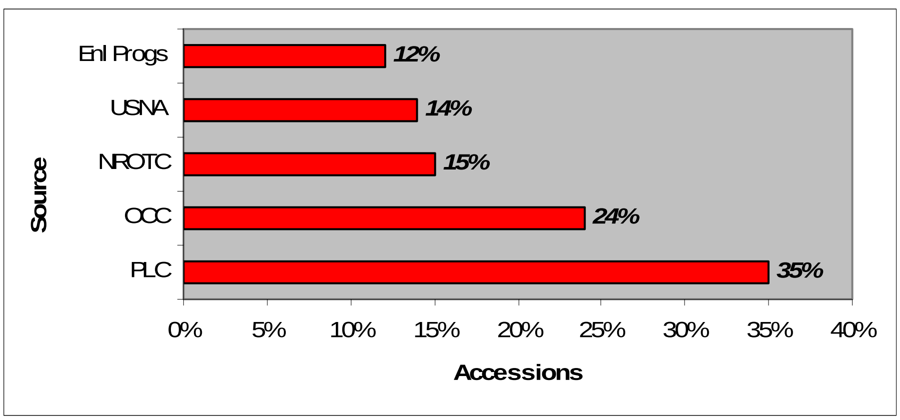

Figure 1. Approximate Percentages of Marine Officer Accessions by Commissioning Source (From HQMC, 2008a)

Finally, it is important to mention that a limited number of aviators are selected from annual Field Accession Boards held at Headquarters, U.S. Marine Corps (HQMC). The Field Accession Boards and accession sources are described more fully below.

a Primary Commissioning Sources

The PLC program was designed for college freshmen, sophomores, and juniors. To be eligible for enrollment, an applicant must be a full-time student who has "completed an academic term with a grade point average of at least 2.0 on a 4.0 scale" (HQMC, 1989). Although PLC participants have no military obligation during the academic school year, they are required to attend Officer Candidate School (OCS) during the summer months.[2] College freshmen and sophomores attend two six-week OCS sessions while juniors attend one ten-week session. Participants receive basic military pay during OCS and are eligible for tuition assistance upon completion of the first six-week or the ten-week OCS session. Upon graduation, PLC candidates are commissioned as second lieutenants and proceed to The Basic School (TBS) in Quantico, Virginia for six months of additional indoctrination training. Regardless of commissioning source, those selected for aviator programs incur six-to-eight years of obligated service upon completion of flight training (HQMC, 2003).

The OCC program was designed for college seniors and those who have already attained a baccalaureate degree. Participants receive basic military pay during the single 10-week OCS session they are required to attend. They receive their commission following graduation from OCS and proceed directly to TBS.

The NROTC (Marine option) program is available to high school graduates and current college or university students. Although not required for participation, fully-funded NROTC scholarships are available through a competitive selection process. Officer candidates or "midshipmen" who enroll in NROTC participate as full members of their institution's NROTC command during the academic school year. They are required to complete a series of Naval science courses and to wear military uniforms at least once a week. NROTC

[2] OCS is a six to ten-week Marine officer screening and evaluation program at Marine Corps Base Quantico, Virginia.

(Marine option) candidates are also required to attend a condensed, six-week OCS session referred to as “bulldog” during the summer months. Once they have completed OCS and attained their undergraduate degree, NROTC (Marine option) midshipmen are commissioned as second lieutenants and proceed to TBS for follow-on training.

The USNA in Annapolis, Maryland is one of five Service academies in the United States. Appointment to the USNA is a highly competitive process available to high school graduates only and normally requires Presidential, Vice Presidential or Congressional nomination (USNA, 2008). In addition to fully-funded tuition, fees, and room and board, all USNA midshipmen receive monthly basic pay, medical and dental care, and access to all military facilities and services normally available to active duty members. Each year, the Marine Corps selects a small number of USNA midshipmen for service as Marine officers. Those selected are commissioned as second lieutenants upon graduation and proceed directly to TBS. USNA midshipmen are not required to attend OCS.

b. Enlisted Commissioning Programs

Eligible enlisted Marines can pursue commissioning through one of three enlisted-to-officer programs: the Meritorious Commissioning Program (MCP), the Enlisted Commissioning Program (ECP), and the Marine Enlisted Commissioning Education Program (MECEP). Participation requires selection by HQMC and is highly competitive. Once commissioned through any of these programs, participants report to TBS. Qualified enlisted Marines can also apply for an NROTC scholarship or appointment to the USNA and participate in those programs, as described above.

Enlisted Marines without a four-year degree but who have attained at least 75 college credits and who have demonstrated exceptional potential for service as a Marine officer are eligible for the MCP. Qualified Marines must have achieved a percentile score of at least 74 on the AFQT and must be

recommended by their Commanding Officer (HQMC, 2002). If selected, candidates must complete one ten-week OCS session before reporting to an NROTC-affiliated college or university (HQMC, 2002). MCP participants receive their commission after attaining an undergraduate degree.

Marines who have already earned a four-year degree from an accredited institution and who have demonstrated potential for commissioned service are eligible to apply for the ECP. Those selected report directly to OCS and are commissioned after completing one ten-week session.

Finally, the MECEP was designed for outstanding enlisted Marines without an undergraduate degree. Applicants must have achieved either a minimum percentile score of 74 on the AFQT, 1000 on the Scholastic Aptitude Test, or 22 on the ACT college entrance exam (HQMC, 2008b). Candidates must also have graduated within the top 50 percent of their high school class. Non-high school graduates must have a percentile score of at least 75 on each subtest of the General Educational Development (GED) test (HQMC, 1994). Those selected for MECEP report to the NROTC unit at the college or university to which they have been accepted to complete their studies. While MECEP participants are not NROTC midshipmen per se, they do participate in the Naval science program and are required to complete select Naval science courses prior to graduation. MECEP Marines retain their active duty rank and continue to receive all pay and entitlements during schooling. They normally attend the six-week "bulldog" OCS session following their first academic year and are commissioned once they have earned their baccalaureate degree.

c. Field Accession Boards

As needed, the Marine Corps also selects a limited number of aviators through Field Accession Boards convened by HQMC. The fiscal year 2009 Field Accession Board, which convened on 9 December 2008, sought applications to fill only three student-pilot positions (HQMC, 2008c). These

boards provide active duty Marine officers with fewer than five years commissioned service with the opportunity to compete for a student-aviator position.

2. Basic Eligibility Requirements

Chapter 2, volume 3 of the MPPM provides the basic eligibility criteria for service as a commissioned officer and Naval aviator. In addition to meeting strict moral standards, all applicants must meet the requirements listed below (HQMC, 1989).

- be a citizen of the United States,
- complete an aviation physical,
- attain a baccalaureate degree from an accredited college or university,
- not have been previously separated from any military aviation training program,
- attain a passing score on the latest version of the ASTB.

B. AVIATION SELECTION TEST BATTERY (ASTB)

1. Overview

The ASTB is used principally by the U.S. Navy, Marine Corps, and Coast Guard to screen applicants for their aviation programs. The Navy and Coast Guard also use the ASTB to determine eligibility for their commissioned officer programs. The battery has its roots in the aviation selection tests developed in the 1940s and that have evolved considerably over the past six decades (Albert, Blower, & Williams, 1999). The Naval Operational Medicine Institute (NOMI) in Pensacola, Florida and Educational Testing Service in Princeton, New Jersey completed the last major revision of the battery in 1992 (Boyd, 2003, p. 15). In its current form, the ASTB consists of six tests: Math Skills, Reading Skills, Mechanical Comprehension, Spatial Apperception, Aviation and Nautical Information, and an Aviation Supplemental Test. Weighted raw scores from

these exams are combined into four ratings: the Academic Qualifications Rating (AQR), Pilot Flight Aptitude Rating (PFAR), Flight Officer Flight Aptitude Rating (FOFAR), and Officer Aptitude Rating (OAR) (Williams et al., 1999). The AQR, PFAR, and FOFAR ratings range from one to nine while the OAR rating ranges from 20 to 80. The AQR and both flight aptitude ratings were designed to predict flight school performance as well as attrition (Naval Aerospace Medical Institute, (NAMI), 2007). The separate Services determine eligibility for their aviation programs based on a combination of these two scores, AQR/PFAR for pilots and AQR/FOFAR for NFOs. Of note, the Biographical Inventory subtest, which had been used to predict flight school attrition, was discontinued in April 2002 (Boyd, 2003). Also, NAMI is currently revising the ASTB. The new test will likely include psychomotor, divided attention, and personality assessments. NAMI expects that the new test will be released sometime during fiscal year 2010 and that it will better predict student-aviator performance and attrition.

Thousands of candidates take the ASTB each year in both pencil-and-paper and computer-based formats. The test is "controlled by NOMI and administered at Navy Recruiting Districts, NROTC units, Marine Corps Officer Selection Offices, and at numerous other permanent custody sites" (NAMI, 2008). Candidates can take the test no more than three times since it is available in only three different forms. Figure 2 shows the mean ASTB test scores, by Service, for over 25,279 candidates from fiscal year 2003 to fiscal year 2006.

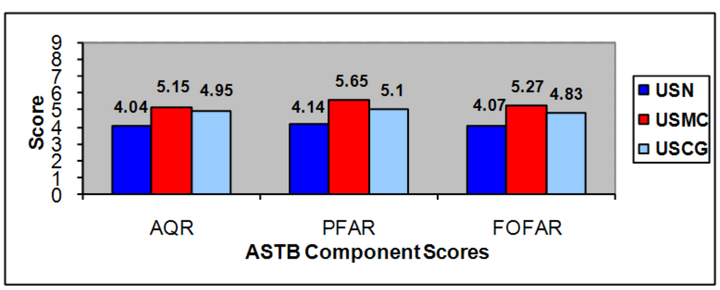

Figure 2. Mean ASTB Scores by Service, FY2003-FY2006 (From NAMI, 2006)

Figure 2 clearly shows that Marine Corps test candidates, on average, have historically achieved slightly higher academic and flight aptitude ratings than test takers from the other Services.

2. Validity

Many studies have examined the predictive validity of the ASTB ratings. More specifically, they have examined the correlation between the academic and flight ratings and student-aviator performance during Aviation Preflight Indoctrination (API) and "primary," the first two stages of formal flight training. For example, Albert, Williams, and Blower (1999) examined data for 2,852 student-pilots and NFOs and reported a "moderately strong" relationship with coefficients of 0.47 and 0.36, respectively. In other words, they reported a correlation coefficient between AQR and performance during API of 0.47 and a coefficient between FAR and performance during primary of 0.36. Their results were very similar to those of earlier studies and to those currently reported by NOMI. Hiatt, Mayberry, and Sims (1997) reported correlation coefficients of 0.42 and 0.40, while Frank and Baisden (1993) estimated slightly lower coefficients of 0.40 and 0.27 (Williams et al., 1999). NOMI currently reports the predictive validity of the AQR and PFAR for student-pilot performance during API and primary to be 0.45 and 0.35, respectively (NAMI, 2008).

The variation in these reported coefficients seems significant. The question, however, is whether the variation is due to changes in the student-aviator population, the flight training curriculum or grading criteria, or study design. Interestingly, Hunter and Burke (1994) conducted a meta-analysis of 68 pilot selection measures studies from 1940 to 1990 and found that decade of study and sample size accounted for a significant amount of the observed variance in the validities reported (pp. 303-305). In addition, considering that the ASTB has evolved over six decades, these validities may appear low. Damos

(1996) offers various explanations for this, including range restriction and the use of a dichotomized “pass-fail” criterion when determining the correlation coefficients (pp. 202-203).

Of greater interest in this study is how well the ASTB predicts attrition from training. In 2006, NAMI reported correlation coefficients between 0.15 and 0.18 for U.S. Navy and Marine Corps student-pilots and NFOs (NAMI, 2006). While these coefficients are much lower than those previously described, the correlations were still significant. This suggests that student-aviator attrition is associated with ASTB scores.

3. Marine Corps ASTB Minimum Scores Policy

The Marine Corps’ current ASTB minimum scores policy states that Marine pilot and NFO candidates must achieve academic and flight aptitude ratings of at least 4/6, respectively, and that waiver requests may be submitted for up to one point in either score but not both (HQMC, MCRC, 2008). In other words, possible ASTB score combinations for those that are granted a waiver include 3/6 to 3/9 and 4/5 to 9/5. Candidates may only submit waiver requests after their third attempt to meet the Corps’ minimum scores and approval authority rests with the Commanding General, MCRC, with concurrence of the Marine Corps Deputy Commandant for Aviation (HQMC, MCRC, 2008). Furthermore, the Deputy Commandant, M&RA limits the number of ASTB waivers granted annually to a percentage of total aviation accessions as necessary. A review of the Marine Corps’ Manpower Accession Plans for fiscal years 2005-2009 revealed that waiver approvals were limited to ten percent of total aviator accessions each year. The accession plans prior to fiscal year 2005 provided no evidence of limits on the number of waivers.

Evidence of the Marine Corps’ 4/6 minimum scores policy dates back to at least 1989. At that time, however, waiver requests were considered for up to one point in both ratings, that is, for score combinations as low as 3/5 (HQMC, 1989). It is unknown how long that policy remained in effect. By at least 1996 the

Marine Corps had decided not to allow waivers, since it was selecting enough candidates at the 4/6 cutoff and the waivers seemed to only negate the cost-saving benefits provided by the ASTB as a valid predictor of flight school success (Dean, 1996). By at least fiscal year 2006 Marine Corps policy had changed again to allow ASTB waiver requests for no more than one point in either rating but not both (HQMC, MCRC, 2006).

C. MARINE AVIATION FLIGHT TRAINING PIPELINE

Marine pilots are trained to fly a variety of aircraft, including fixed-wing (jets), rotary-wing, tilt-rotor, and multi-engine propeller airframes. Marine Corps fixed-wing jet aircraft include the F/A-18 C/D "Hornet," the EA-6B "Prowler," and the AV-8B "Harrier II." Rotary-wing aircraft include the AH-1W "Super Cobra" attack helicopter, UH-1N "Twin Huey," CH-46E "Sea Knight" medium lift helicopter, and the CH-53D "Sea Stallion" and CH-53E "Super Stallion" heavy lift helicopters. Tilt-rotor aircraft include the MV-22 "Osprey." Multi-engine propeller aircraft include the KC-130J "Hercules." Marine NFOs, on the other hand, are trained to fly only in either the F/A-18 or the EA-6B. F/A-18 NFOs serve as Weapons Systems Officers while EA-6B NFOs serve as electronic countermeasure officers. As such, NFOs are responsible for navigating, communicating, and employing aircraft weapons systems, thereby allowing the pilot to focus primarily on flying the aircraft (Murray, 1998). Although not pilots, all NFOs are nonetheless trained in the basics of flight. The Marine aviation flight training pipeline is depicted in Figures 3 and 4 and described in the discussion that follows.

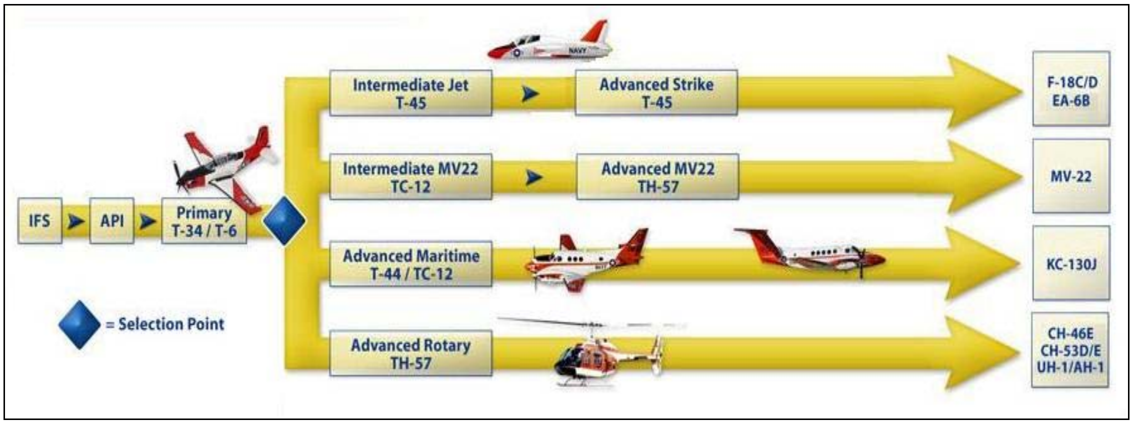

Figure 3. Marine Pilot Training Pipeline (After CNATRA, 2008)

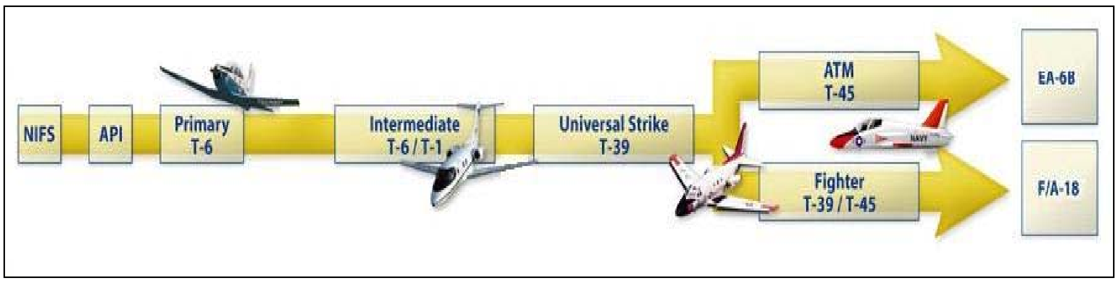

Figure 4. Marine NFO Training Pipeline (After CNATRA, 2008)

1. Introductory Flight Screening

The long road to earning aviator wings begins with the Introductory Flight Screening (IFS) program. Once selected for a Marine aviator program, whether before or after commissioning, candidates attend IFS at certified pilot schools in Annapolis, Maryland, Quantico, Virginia, or Pensacola, Florida areas. IFS is fully-funded by the Department of the Navy (DoN) and “provides students with a maximum of 25 hours of civilian aviation flight training and the private pilot ground school prior to beginning the (formal) Naval aviation training pipeline” (DoN, 2008). Naval Aviation Schools Command (NAVAVSCOLSCOM) in Pensacola, Florida manages the IFS program, which was designed to reduce attrition in follow-on stages of training by screening out those who lack the proper “determination, motivation, or aeronautical adaptability required to succeed in flight training” (CNATRA, 2007). Aviation candidates who possess a civilian

private pilot certificate or license are exempt from the program. Following IFS, commissioning, and graduation from TBS, all Marine student-aviators report to Marine Aviation Training Support Group-21 in Pensacola, Florida to begin the more formal aviation training pipeline with NAVAVSCOLSCOM.

2. Aviation Preflight Indoctrination

Four phases of aviation training follow IFS, not all of which are required for each airframe. The four phases are Aviation Preflight Indoctrination (API), primary, intermediate, and advanced. Regardless of program (pilot or NFO) or aircraft type, all Marine student-aviators attend API at the Naval Air Station (NAS) in Pensacola, Florida. API is an intense six-week academic course in subjects such as engineering, the fundamentals of aerodynamics, air navigation, aerospace physiology, and aviation weather (CNATRA, 2008). Students also participate in a rigorous physical training program, including water survival. Following API, student-pilots proceed to either NAS Whiting Field in Milton, Florida, NAS Corpus Christi, Texas, or Vance Air Force Base in Enid, Oklahoma for primary flight training. Student-NFOs remain in Pensacola for the primary phase under instruction of Training Air Wing-Six.

3. Primary – Advanced Flight Training

Primary training for student-pilots lasts approximately 22 weeks. It begins with additional academic training in what is referred to as “ground school”. Subjects include, but are not limited to, flight planning, instrument flight rules, aircraft systems, and visual navigation (CNATRA, 2008). Students then receive flight simulator instruction before completing basic flight training in one of two aircraft, the T-34 “Turbomentor” or the T-6A “Texan II.” The primary flight training phase for student-pilots is provided in six stages: Familiarization, Basic Instruments, Precision Aerobatics, Formation, Night Familiarization, and Radio Instruments (CNATRA, 2008). Student-NFOs must complete a condensed version of the pilot primary curriculum that lasts approximately 15 weeks.

Specific aircraft pipeline selections are typically made after the primary phase and are based on the current needs of the Marine Corps, student performance, and student preferences.

Student-pilots selected for the multi-engine propeller pipeline proceed directly to NAS Corpus Christi for advanced flight training. Rotary-wing student-pilots also proceed directly to the advanced phase and complete their flight training at NAS Whiting Field. Tilt-rotor students complete intermediate flight training in the TC-12 “Huron” turboprop aircraft, followed by the advanced phase where they fly the TH-57 “Sea Ranger” helicopter. Student-pilots selected for the jet aircraft pipeline proceed to either NAS Kingsville, Texas or NAS Meridian, Mississippi where they complete their intermediate and advanced training phases in the T-45 “Goshawk.” Student-NFOs complete the intermediate phase at NAS Pensacola with either Training Squadron-4 or Training Squadron-6. Their intermediate training phase includes airways and instrument navigation, and visual navigation flights in the T-6A, T-39 “Sabreliner” and T-1A “Jayhawk” jet aircraft. Student-NFOs then complete the advanced training phase with Training Squadron-86 in the T-39 and the T-45.

4. Fleet Replacement Squadron

Upon successful completion of advanced flight training, student-pilots and student-NFOs receive their aviator wings. They then proceed to their respective Fleet Replacement Squadron (FRS) where they are trained for up to nine months in the specific aircraft for which they have been selected. Afterwards, they report to their first operational squadron for duty.

D. FLIGHT SCHOOL ATTRITION

1. Overview

Despite the rigorous screening process for Marine aviators, historic attrition rates from API through the advance stage of training have still averaged

18% for Marine student-pilots and 22% for Marine student-NFOs (NAMI, 2006). Student attrition may be voluntary or involuntary, and attrition reasons are generally classified into one of the following ten categories: performance, non-academic, medical, legal, death, physical, fraudulent enlistment, convenience of the government, disenrollment, and miscellaneous (CNATRA, 2007).

Students who attrite for performance reasons include those who are unable to achieve academic or flight training standards. Non-academic failures include students who either demonstrate or express a lack of training motivation or those who attrite for administrative reasons such as unsuitability for military service or personal hardship. Those who express a lack of motivation or who "drop on request" can do so during any phase of training and their request must be honored (CNATRA, 2007). Historically, the academic failure, flight failure, and drop on request categories have constituted the vast majority of student-aviator attrition (NOMI, 2006).

Students who attrite for medical reasons include those who are found to be medically or physically unsuitable for service as an aviator. Examples of legal attrition reasons include misconduct, conviction by civilian authorities, desertion, and substance abuse. Attrition due to death or fraudulent enlistment is self-explanatory. Physical attrition reasons include swimming or physical fitness test failure and obesity. Students with pre-service, non-medical disqualifying conditions are disenrolled by reason of convenience of the government. The disenrollment category is used in cases where students' training is terminated due to course cancellation or upon request of the Services. Finally, a miscellaneous category is used for those who attrite from training for reasons not covered by any other category.

Regardless of the reason for attrition, authority to disenroll a student from training rests with either the Commanding Officer, NAVAVSCOLSCOM or one of five Training Air Wing Commanders, depending on the training phase (CNATRA, 2007). Whether the student remains in the Service and is reassigned or is

separated from the Marine Corps obviously depends on the attrition reason. Ultimately, such decisions are made by HQMC.

2. Review of Prior Studies

Considering the extremely high costs of aviation training, it is not surprising that many researchers have studied the effects of various factors on student-aviator performance and attrition. A review of previous literature reveals that the vast majority of studies have examined the effects of ASTB scores, gender, race and ethnicity, commissioning source, and educational background. A summary of prior research that examines these and various other factors is provided below. It should be noted that, while in some cases researchers have included Marine student-aviators in their studies, most have focused exclusively on Navy student-pilots and NFOs.

For example, Reinhart (1998) examined the relationship between observable characteristics and performance and attrition during the primary training phase for 272 student-pilots who graduated from the USNA during 1995 and 1996 (p. 5). He used multivariate regression analysis to predict student attrition and performance while controlling for gender, age, marital status, race and ethnicity, ASTB scores, USNA achievement ratings, undergraduate major, and previous flight experience. After correcting for selection bias, Reinhart found that only ASTB scores, performance at the USNA, and previous flight experience were significant predictors of flight training performance. Limitations to his study include the overall small sample size and the very limited number of minority and female observations. Reinhart admits that this may have contributed to the apparent insignificance of these variables. Grouping all minorities together, Reinhart was also unable to determine whether there were significant effects for students of different races or ethnicities (p. 45).

Murray (1998) also examined the effect of various demographic factors on student-NFO attrition from flight training. He used CNATRA and U.S. Navy Officer Master File data on 1,165 student-NFOs that began flight training

between 1991 and 1995 (p. 20). Murray concluded that commissioning source was a significant predictor of attrition at the 5% level (p. 37). Specifically, he found that USNA graduates attrited at the lowest rate, followed by those from NROTC and Navy OCS accession sources (p. 39). He also found that students with technical undergraduate degrees performed significantly better than did those with non-technical degrees and that white students attrited for performance reasons at significantly lower rates than did racial and ethnic minorities (p. 40).

Wahl (1998) used classification and regression tree techniques to examine the effect of Biographical Inventory (BI) scores from the ASTB on student performance and attrition during primary (p. 1). He used NOMI data on student pilots who participated in API and primary between September 1993 and March 1997 (p. 17). Since the BI was discontinued in 2002, his principal results are not addressed. Wahl's study is of interest, however, since his attrition models controlled for race and ethnicity. Wahl concluded that black, Hispanic, and Asian student-pilots attrited from API at a significantly higher rate than did whites and American Indians (p. 46).

Reis (2000) used classification and regression trees as well as multivariate logistic regression to estimate the effect of undergraduate major on flight school performance and success, regardless of attrition reason. His dataset included 2,612 U.S. Navy student-aviators who participated in API and primary flight training between 1990 and 1999 (p. 15). NFOs were excluded along with student-pilots who accessed from sources other than the USNA, NROTC, and U.S. Navy OCS. In his analysis, Reis controlled for college rating, commissioning source, ASTB scores, and race and ethnicity (p. 2). Reis concluded that student-aviators with engineering and other technical degrees performed better during API and primary and had a significantly greater chance of completing flight school than did those with non-technical degrees (p. 37). He also found ASTB scores, USNA attendance, and race/ethnicity to be statistically significant predictors of flight school success (p. 42).

Hafner (2000) examined the effects of gender, race and ethnicity, midshipmen performance grades, undergraduate major, and personality type (Myers-Briggs Type Indicator) on service selection, assignment, and student-NFO attrition for 475 USNA graduates from 1992 through 1996 (p. 26). Overall, Hafner's attrition model was insignificant at the 5% level (p. 61). All of the variables in his model, except cumulative academic point rating (GPA), were also insignificant (p. 66). Hafner suggests that his results are consistent with prior studies, which is obviously not true. It is quite possible that the lack of significance was due to the relatively small sample size, the fact that he did not control for ASTB scores, and that the dependent variable in his attrition regression model included attrition for any reason (p. 29). One would not expect variables such as academic performance and undergraduate major to predict medical, physical, legal, or administrative attrition.

Boyd (2003) estimated the effects of gender, race, ASTB scores, USNA grades and class standing (Order of Merit), and undergraduate major on student-pilot performance and attrition during the API and primary training phases. She used both linear and logistic regression to analyze USNA and NOMI data for 961 USNA graduates from 1995 to 1998 who were assigned as U.S. Navy and Marine Corps student-pilots (p. 9). Boyd concluded that USNA academic grades and Order of Merit were significant predictors of student-pilot performance and attrition at the 1% level of significance. ASTB academic and flight aptitude ratings were also significant at the 1% level. Gender (female) was a significant predictor of poorer performance during API only (p. 47). Surprisingly, while not significant, the effect of being female on performance was positive for the primary phase of training but negative in all of Boyd's API performance and attrition models. Contrary to findings in most of the literature, race was generally not significant (p. 49). However, students with non-technical undergraduate degrees were significantly more likely to attrite and to perform worse during API than those with technical degrees (p. 55).

E. SUMMARY

For most Marine-aviator candidates, achieving the Marine Corps' cutoff scores on the ASTB marks the beginning of a very long road to becoming a pilot or NFO. Even before beginning formal flight training, candidates must complete several challenging indoctrination programs designed to screen out individuals who lack the motivation and ability to serve as a Marine officer and aviator. Those who are successful must then complete a rigorous academic and physical aviation training program. Although most aviators eventually earn their wings, historic attrition rates have averaged around 18% for student-pilots and 22% for student-NFOs. Many different reasons can help to explain attrition. Nevertheless, academic failure, flight failure, and drop on request have historically constituted the vast majority of student-aviator attrition.

Because of the high cost of aviator attrition, many researchers have set out to identify factors that predict Naval flight training performance and disenrollment. The studies reviewed here suggest that the significant predictors are ASTB scores, undergraduate degree, commissioning source, and race and ethnicity.

III. RESEARCH DATA AND PRELIMINARY ANALYSIS

The purpose of this chapter is to describe the data used in this research. The chapter begins with a review of the data sources and procedures followed to merge two principal datasets. Then, the coding of the dependent and explanatory variables from the merged dataset is explained, and the effect of each variable on flight school attrition is suggested. Finally, several tables and figures are presented, along with the results of preliminary statistical tests to describe the relationship between flight school attrition, Aviation Selection Test Battery (ASTB) waivers, and the other explanatory variables used in this study.

A. DATA SOURCES

The principal data for this research were provided by the Naval Air Training Command (CNATRA) and were derived from the electronic Aviation Training Jacket (eATJ) database. This database is updated manually from hardcopy training jackets when students complete or attrite from training. The original dataset contained ASTB scores and aviation training data for Marine Corps students that reported to Aviation Preflight Indoctrination (API) on or after 1 January 1999. The file contained 3,234 records and was merged by Social Security Number (SSN) with demographic, educational background, and commissioning source data from the Total Force Data Warehouse (TFDW). While these data were also included in the eATJ, TFDW was used when possible since it is the Marine Corps' historical personnel database and a much more authoritative data source. Since TFDW captures information for all Marines on a monthly basis, the "snap-shot" date closest to each student's API report date was used for the merge; this resulted in 3,224 matching records. After representatives from Marine Corps Recruiting Command (MCRC) completed the merge, all SSNs were replaced with unique, non-personally identifiable numbers. The loss of ten records resulted from non-matching SSNs and is likely attributable to data entry errors in the eATJ database. The dataset was then

reduced to 3,071 observations due to duplicate student records, ASTB scores outside of the feasible range, and missing observations for other key variables. Finally, since this study focuses on flight school attrition for performance or motivation reasons only, students who attrited for all other reasons were dropped from the sample. The final dataset included 2,990 observations.

B. DESCRIPTION OF VARIABLES

The following discussion describes how the variables used in this study were created from the merged dataset. The effect of each variable on flight school attrition is also suggested. A summary appears in Table 2 at the end of this section.

1. Dependent Variable

Attrite - the dependent variable "attrite" was derived from the "student attrite reason" field in the eATJ database. Since students who were disenrolled for reasons that could not be attributed to substandard performance or attitude were dropped from the dataset, the remaining eight values for this field were sorted into academic, flight, and motivation attrition categories. The "attrite" variable, therefore, was then defined as attrition for any of these reasons. In other words, this variable assumes a value of one for students who were disenrolled for academic performance, flight performance, or lack of motivation reasons and zero otherwise. Table 1 provides a list of the eight descriptive reasons that were sorted into each attrition category.

Table 1. Categorical Attrition Reasons

Academic	Flight	Motivation
Lack of Comprehension	Flight Failure-Pilot	Drop on Request
Lack of Language Proficiency	Flight Failure-NFO	Negative Training Attitude
Lack of Reading Skills		
Academic Other		

It should be noted at this point that there were three important reasons for including students who were disenrolled from training for “motivation” reasons as attriters. First, the Naval Aerospace Medical Institute (NAMI) defines attrition as disenrollment for academic, flight, or motivation reasons in their ASTB validation studies. Second, an individual’s Pilot Flight Aptitude Rating (PFAR) is heavily weighted by his or her score on the Aviation and Nautical Information (ANI) subtest. Because the ANI is “largely a test of knowledge and not aptitude,” it is possible for test-takers to improve their PFAR by studying aviation terminology and concepts. It is arguable that candidates who are highly motivated toward a career in aviation are more likely to seek out this information and better prepare themselves to take the ASTB. Finally, in their 2006-2007 biannual attrition report, the Naval Operational Medicine Institute (NOMI) disclosed that the motivation attrition category includes students who believed that they would have been disenrolled eventually for flight or academic reasons (p. 11)

2. Explanatory Variables

The choice of independent variables used in this research was based primarily on the results of earlier studies and was limited by the data that were available. The variables include the key independent variable, ASTB waiver, demographics (age, gender, marital status, race and ethnicity), undergraduate degree major (engineering, other technical, and non-technical), commissioning source, and indicator variables for fiscal year cohorts. A detailed description of each variable is provided below.

Age - this continuous variable was calculated as the difference between the students’ birthdates and their API report dates, and therefore measures the students’ ages at the beginning of flight training. It is expected that age will have a positive, but small, effect on attrition. In other words, it is expected that older students attrite from training at a higher rate. On average, older students may find the rigorous flight school curriculum to be more challenging, particularly if they have been out of school for some time.

Gender - the **female** indicator variable was generated from the TFDW "sex" variable. It assumes a value of one for women and zero otherwise. Results of previous studies suggest that the effect of this variable will be insignificant, that is, women are no more or less likely to attrite from training. However, it is included in this study to test whether these results hold true for female Marine Corps student-aviators. Since women have historically achieved lower ASTB test scores than men, it is expected that the effect of this variable on attrition will be positive.

Marital Status - the **married** indicator variable was created from the TFDW "Marital Status Code" variable and assumes a value of one for married students and zero otherwise. Since a TFDW "snap-shot" was used to merge the eATJ and TFDW data, this variable represents the students' marital status upon reporting to API. Given that the data did not allow for measurement of changes in this variable throughout training, the effect of being married on attrition is expected to be very small, if significant. Arguably, the effect could be positive or negative. Married students may be more determined since their spouses also depend on their success. At the same time, those who are married may have more personal commitments that detract from their studies, which could ultimately result in poorer performance.

Race/Ethnicity - the CNATRA dataset was used to generate five race/ethnicity indicator variables: **white, black, other_race, hispanic,** and **non-hispanic**. For instance, the white indicator variable assumes a value of one for students that are white and non-Hispanic. The number of lost observations was reduced significantly by replacing missing values for these variables with data from TFDW. Since minority students have historically attrited at higher rates than white students, the effect on attrition of being Hispanic or of races other than white is expected to be positive and significant.

Undergraduate Major - entries in the "student_major" field of the CNATRA dataset were sorted categorically and used to generate three indicator variables: **eng_deg, other_tech_deg,** and **non_tech_deg**. The "eng_deg" or

“engineering degree” variable assumes a value of one if a student majored in engineering and zero otherwise. The “other technical degree” and “non-technical degree” variables were coded in a similar manner. Again, missing or indeterminable values were replaced with data from TFDW. Based on prior research, students with engineering or other technical undergraduate degrees are expected to attrite at a lower rate than those with non-technical degrees. Appendix A provides a list of the undergraduate degrees from the dataset that represent each indicator variable.

Commissioning Source - the “current source of entry” field from the TFDW dataset was used to generate indicator variables representing five accession sources: **plc, occ, nrotc, academy,** and **enl_comm_progs**. Each variable assumes a value of one for students who participated in that program and zero otherwise. It is expected that OCC and enlisted commissioning program participation will have a positive effect on attrition as these programs may access more students with non-traditional college education such as courses taken online or validated through the DANTES Subject Standardized Tests and College Level Examination Program (CLEP) tests. In addition, based on prior research, graduates from the Service Academies are expected to attrite at lower rates than are all other students. Likewise, it is expected that NROTC graduates, of whom many were granted competitive scholarships, perform better academically and therefore attrite at lower rates than do PLC, OCC, and enlisted commissioning program participants.

Fiscal Year Cohorts - the CNATRA “API date reported” variable was used to generate eight indicator variables representing fiscal years 1999-2006. For example, students who reported to API between 1 October 2005 and 30 September 2006 were assigned to the 2006 fiscal year cohort. As a reminder, the fiscal year 1999 cohort was limited in that data were not available prior to 1 January 1999. The fiscal year cohort variables were created to capture potential differences in the student cohorts due to changes in flight school

curriculum and instructors as well as changes in economic conditions. It is unclear what effect, if any, these variables will have on attrition.

Program - The **nfo** indicator variable assumes a value of one for students assigned to the NFO program and zero otherwise. This variable was created to facilitate data analysis and to account for program differences during the attrition simulation that is explained in Chapter IV.

ASTB Waivers - as discussed in Chapter II, the Marine Corps' academic and flight aptitude cutoff ratings are four and six, respectively, for both pilots and NFOs. Current policy allows for a one-point waiver in either rating but not both for no more than ten percent of aviator accessions each fiscal year. Possible waiver score combinations include 3/6 through 3/9 and 4/5 through 9/5. Therefore, any student in the sample with an AQR rating of three or a FAR rating of five would have required an ASTB waiver. Since data were not available that specifically identified Marine student-aviators who were granted an ASTB waiver, this logic was used to derive an **ASTB_waiver** indicator variable from the student ASTB score fields in the CNATRA dataset. This variable assumes a value of one for students with ratings below the Marine Corps' minimums and zero otherwise. Given the validity of the ASTB as a predictor of flight school performance and attrition, students with a test-score waiver are expected to attrite at higher rates than are those without a waiver.

In some models, the "ASTB_waiver" variable, which indicates the presence or absence of a waiver, was used as a predictor. In other models, separate variables representing individual waiver score combinations were used.

Table 2. Summary of Variable Descriptions

Variable	Definition	Exp. Effect
Dependent		
attrite	=1 if attrite for flight, academic, or motivation reasons; else 0	N/A
Key Explanatory Variable		
ASTB_waiver	=1 if ASTB scores below USMC minimums; else 0	+
Demographics		
age	student's age (in years)	+
female	=1 if female; else 0	+
married	=1 if married; else 0	+/-
white	=1 if white; else 0	-
black	=1 if African American; else 0	+
hispanic	=1 if Hispanic; else 0	+
other_race	=1 if American Indian, Alaskan Native, Asian, Native Hawaiian, or Other Pacific Islander; else 0	+
Undergraduate Degree		
eng_deg	=1 if engineering degree; else 0	-
other_tech_deg	=1 if other technical degree; else 0	-
non_tech_deg	=1 if non-technical degree; else 0	+
Commissioning Source		
plc	=1 if PLC commissioning source; else 0	+
occ	=1 if OCC commissioning source; else 0	+
nrotc	=1 if NROTC commissioning source; else 0	-
enl_comm_progs	=1 if commissioning source any enlisted-to-officer program; else 0	+
academy	=1 if Service Academy graduate; else 0	-
Program	=1 if student-NFO program; else 0	+/-
Fiscal Year Cohorts		
fy99	=1 if API report date during FY99; else 0	+/-
fy00	=1 if API report date during FY00; else 0	+/-
fy01	=1 if API report date during FY01; else 0	+/-
fy02	=1 if API report date during FY02; else 0	+/-
fy03	=1 if API report date during FY03; else 0	+/-
fy04	=1 if API report date during FY04; else 0	+/-
fy05	=1 if API report date during FY05; else 0	+/-
fy06	=1 if API report date during FY06; else 0	+/-

C. PRELIMINARY DATA ANALYSIS

This section provides a preliminary analysis of the data used in this research. Analysis began with an examination of the distribution of ASTB scores and attrition reasons for the 2,990 student-aviators in the sample. Then, the

study looks at the relationships between ASTB waivers and flight school attrition, and the explanatory variables previously described. For this analysis, a series of cross-tabulation or contingency tables were created to study the frequencies of different combinations of the variables. The statistical software, *STATA*, was then used to perform chi-squared tests on each table to determine whether sufficient evidence existed to infer that the variables were related. The null hypothesis tested for each table was that there was no relationship between the variables, in other words, that the relative frequencies obtained were what one would expect to obtain by chance if the variables were not dependent. The alternative hypothesis tested was that the variables were related. The chi-squared test statistic was calculated using the formula in Figure 5 where k is the number of cells in the contingency table, f_i are the observed frequencies and e_i are the frequencies expected when the variables are independent (Keller, 2005).

$$\boxed{\chi^2 = \sum_{i=1}^{k} \frac{(f_i - e_i)^2}{e_i}}$$

Figure 5. Chi-squared Test Statistic (From Keller, 2005, p. 558)

The statistical software uses the test statistic and the number of degrees of freedom for each table to calculate an associated p-value, which is then compared to a test significance level. When testing statistical hypotheses, it is generally accepted that a p-value between 0.01 and 0.05 provides strong evidence that the null hypothesis should be rejected in favor of the alternative (Keller, 2005, p. 335). A p-value closer to zero offers greater evidence in support of the alternative hypothesis.

The following discussion summarizes the preliminary data analysis. Additionally, Appendix B provides a summary of the number of observations, mean, standard deviation, and minimum and maximum values for each variable.

1. Distribution of ASTB Scores

Figure 6 provides the distribution of ASTB scores for the 2,647 Marine student-pilots in the sample. Given that these scores represent students who were selected for flight training, the majority of the scores are obviously above the Marine Corps' 4/6 cutoff. In fact, only 200 out of the 2,647 Marine student-pilots (7.5%) achieved a combination of ratings that would have required an ASTB waiver. It is important to note that some possible score combinations do not appear. Students who achieve high flight aptitude ratings typically achieve relatively high academic scores as well. For this reason, it is not unusual that scores such as 3/7 through 3/9, or 4/8 and 4/9 do not appear. Finally, it should be highlighted that, while 90% of the student-pilots (2,388 out of 2,647) achieved an academic rating above four, only 45% (1,187 out of 2,647) scored higher than six on the pilot flight aptitude rating. This suggests that the flight aptitude rating is more of a limiting factor for selection than the AQR.

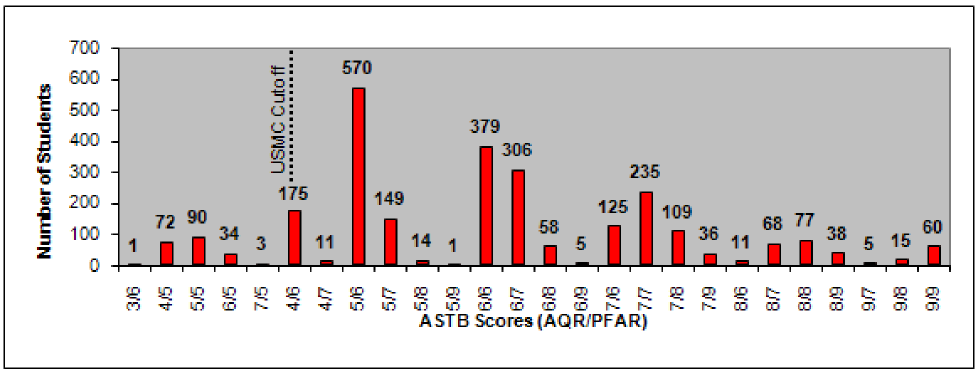

Figure 6. Distribution of Marine Student-Pilot ASTB Scores

Figure 7 provides the distribution of ASTB scores for the 343 Marine student-NFOs in the sample. Of note, it appears that a much higher percentage of student-NFOs scored below the Marine Corps' minimum scores. A total of 56 student NFOs (16%) achieved scores that required an ASTB waiver (4/5, 5/5, and 6/5). Additionally, the percentage of student-NFOs who achieved ratings higher than the Marine Corps' standards appears very similar to that of student

-pilots. Approximately 93% (318 out of 343) achieved an academic rating above four, while only 37% (129 out of 343) scored higher than six on the flight officer flight aptitude rating.

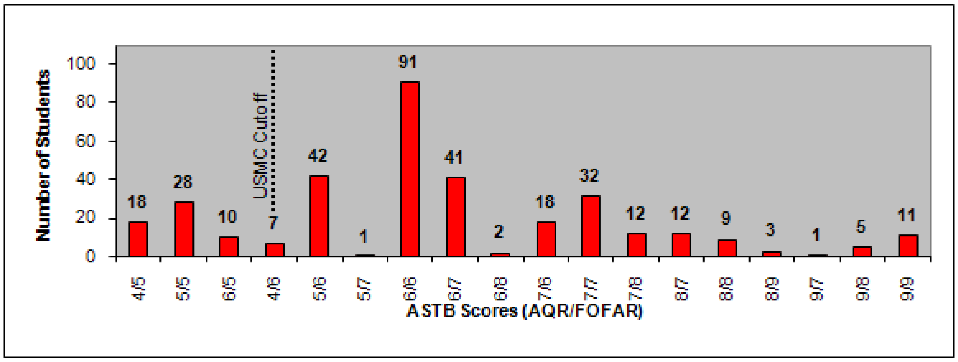

Figure 7. Distribution of Marine Student-NFO ASTB Scores

2. Distribution of Attrition Reasons

Figure 8 provides the distribution of the 448 Marine student-aviators in the sample who were disenrolled from training for academic performance, flight performance, or motivation reasons. Of note, given that the vast majority of Naval student-aviators have historically attrited for one of these three reasons, it is not surprising that 85% of the Marine student-attriters in the original sample of 3,071 students were also disenrolled for these reasons (NAMI, 2006).

Considering the relatively high ASTB academic ratings above, it is not surprising that the percentage of academic failures (9%) is significantly lower than the percentage of flight (53%) and motivation (38%) failures. Of note, the 17.2% (529 out of 3,071) overall attrition rate for the original sample is only slightly lower than the 19% rate reported for Marine student-aviators from fiscal years 1998-2005 (NAMI, 2006).

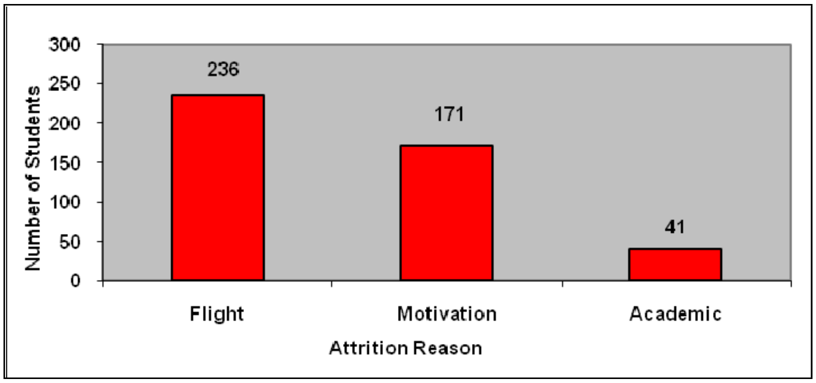

Figure 8. Distribution of Student Attrition by Reason

3. Chi-squared Tests of Contingency Tables

a. Gender

Tables 3 and 4 present the distribution of ASTB waivers and flight school attrition rates by gender for the 2,990 Marine student-aviators in the data sample. These tables present some very interesting results. First, while women make up a relatively small percentage of the student sample (3.9%), they are granted waivers at a much higher rate than are men. Approximately 18% (21 out of 116) of the women in the sample achieved ASTB scores that required a waiver compared with only 8.2% of their male counterparts. Notice the p-value for the chi-squared test associated with Table 3. The null hypothesis tested was that gender is irrelevant as to whether a Marine student-aviator is granted a waiver. Since the p-value is 0.000, it can be concluded at the 1% significance level that ASTB waivers are associated with gender.

Surprisingly, however, Table 4 shows that flight school attrition rates for women (15.5%) and men (15%) are not significantly different. Since the p-value (0.869) is greater than even 10%, one can conclude that whether a student is disenrolled from Naval flight training is not associated with gender. These results are consistent with the literature reviewed in Chapter II, that is, the effect of being female on flight school attrition is not statistically significant.

Table 3. Distribution of Marine Corps ASTB Waivers by Gender

Waiver	*USMC ASTB Waivers by Gender*		
	Female	**Male**	**Total**
No	95	2,639	2,734
	81.9%	91.8%	91.4%
Yes	21	235	256
	18.1%	8.2%	8.6%
All	116	2,874	2,990
	3.9%	96.1%	100%
Pearson chi2 = 14.034 sig. = 0.000 (with 1 df)			

Table 4. Flight School Attrition Rates by Gender

Attrite	*Flight School Attrition by Gender*		
	Female	**Male**	**Total**
No	98	2,444	2,542
	84.5%	85.0%	85.0%
Yes	18	430	448
	15.5%	15.0%	15.0%
All	116	2,874	2,990
	3.9%	96.1%	100%
Pearson chi2 = 0.027 sig. = 0.869 (with 1 df)			

b. Race and Ethnicity

Table 5 provides the distribution of ASTB waivers by race and ethnicity for the student sample. The majority of aviator candidates are white (87.2%), followed by students of “other” races (3.8%), and blacks (2.6%). Students of Hispanic descent constitute only (6.4%) of the sample. Although there is certainly no evidence to suggest that the Marine Corps’ ASTB waivers are used to influence student diversity, it appears that a greater proportion of minority aviator candidates have been granted ASTB waivers. Black candidates received the greatest percentage of waivers (21.8%) among all racial/ethnic

groups. Hispanics received significantly fewer (14.2%), followed by students of “other” races (12.2%) and whites (7.6%). The chi-squared test results indicate that whether a student is granted an ASTB waiver is associated with race and ethnicity.

Table 6 presents the flight-school attrition rates by race and ethnicity. It is important to remember that throughout this study, attriters are defined as students who are disenrolled due to performance (academic or flight) or lack of motivation reasons only. The data in Table 6 suggest that minorities attrite at much higher rates than do their majority counterparts. The overall attrition rate for the sample was 15%. Black students attrited at the highest rate (35.9%), followed by students in the “other” race category (25.2%), and Hispanics (23.2%). Non-Hispanic white students attrited at the lowest rate (13.3%).

Table 5. Distribution of ASTB Waivers by Race/Ethnicity

Waiver	***USMC ASTB Waivers by Race/Ethnicity***				
	White	**Black**	**Hispanic**	**Other Race**	**Total**
No	2,409	61	163	101	2,734
	92.4%	78.2%	85.8%	87.8%	91.4%
Yes	198	17	27	14	256
	7.6%	21.8%	14.2%	12.2%	8.6%
All	2,607	78	190	115	2,990
	87.2%	2.6%	6.4%	3.8%	100%
Pearson chi2 = 30.220 sig. = 0.000 (with 3 df)					

Again, the p-value associated with the chi-squared test statistic is used as the basis for deciding whether to accept or reject the null hypothesis that attrition is not associated with race and ethnicity. In this case, the differences in attrition rates are significant at even the 1% level. These preliminary results support the findings of previous research, that is, minorities are significantly more likely to attrite from Naval flight training.

Table 6. Flight School Attrition Rates by Race and Ethnicity

Attrite	*Flight School Attrition by Race/Ethnicity*				
	White	**Black**	**Hispanic**	**Other Race**	**Total**
No	2,260	50	146	86	2,542
	86.7%	64.1%	76.8%	74.8%	85.0%
Yes	347	28	44	29	448
	13.3%	35.9%	23.2%	25.2%	15.0%
All	2,607	78	190	115	2,990
	87.2%	2.6%	6.4%	3.8%	100%
Pearson chi2 = 51.934 sig. = 0.000 (with 3 df)					

c. Marital Status

The distribution of ASTB waivers by marital status is provided in Table 7. Of note, students who are not married include divorcees. It is not necessarily surprising that more than two thirds (69.2%) of the students in the sample are not married. It seems logical since most student-aviators are young men and women who have recently graduated from college. It is interesting, however, that married student-aviators are significantly more likely to be granted ASTB waivers. Ninety-seven out of 922 (10.5%) married students received waivers compared with only 7.7% of non-married students. This difference is also statistically significant at the 5% level.

Table 8 presents student-aviator attrition rates by marital status. Considering that married students are more likely to be granted an ASTB waiver, it is expected that they will also be more likely to attrite from training. The data support this proposition. Approximately 18% (162 out of 922) of married students attrited compared with only 14% of non-married students. The chi-squared test results reported in Table 8 indicate that whether a Marine student-aviator is disenrolled from flight training for academic, flight, or motivation reasons is also associated with marital status.

Table 7. Distribution of ASTB Waivers by Marital Status

Waiver	*USMC ASTB Waivers by Marital Status*		
	Married	**Not Married**	**Total**
No	825	1,909	2,734
	89.5%	92.3%	91.4%
Yes	97	159	256
	10.5%	7.7%	8.6%
All	922	2,068	2,990
	30.8%	69.2%	100%
Pearson chi2 = 6.533 sig. = 0.011 (with 1 df)			

Table 8. Flight School Attrition by Marital Status

Attrite	*Flight School Attrition by Marital Status*		
	Married	**Not Married**	**Total**
No	760	1,782	2,542
	82.4%	86.2%	85.0%
Yes	162	286	448
	17.6%	13.8%	15.0%
All	922	2,068	2,990
	30.8%	69.2%	100%
Pearson chi2 = 7.005 sig. = 0.008 (with 1 df)			

d. Commissioning Source

Tables 9 and 10 present the distribution of ASTB waivers and flight school attrition rates by commissioning source. Surprisingly, PLC and OCC participants received fewer waivers than students commissioned through NROTC and the Service Academies. It was expected that students who participated in programs offering competitive scholarships would have outperformed their peers on the ASTB and therefore required fewer waivers. It is

interesting, however, that although NROTC and Academy graduates were granted more waivers, they experienced the lowest attrition rates among the five commissioning sources.

Table 9 also reveals that the greatest percentage of ASTB waivers were granted to student-aviators who participated in the Corps' enlisted commissioning programs (21.4%). As expected, they also attrited at the highest rate (19.8%), followed by those commissioned via the OCC (17.1%) and the PLC programs (15.3%). Since the chi-squared tests for both tables were significant, it can be said that ASTB waivers and flight school attrition are associated with commissioning source.

Table 9. Distribution of ASTB Waivers by Commissioning Source

Waiver	***USMC ASTB Waivers by Commissioning Source***					
	PLC	**OCC**	**NROTC**	**Academy**	**Enl Comm Prog**	**Total**
No	881	951	276	431	195	2,734
	92.4%	94.3%	88.7%	91.9%	78.6%	91.4%
Yes	72	58	35	38	53	256
	7.6%	5.7%	11.3%	8.1%	21.4%	8.6%
All	953	1,009	311	469	248	2,990
	31.9%	33.7%	10.4%	15.7%	8.3%	100%
Pearson chi2 = 66.417 sig. = 0.000 (with 4 df)						

Table 10. Flight School Attrition by Commissioning Source

Attrite	***Flight School Attrition by Commissioning Source***					
	PLC	**OCC**	**NROTC**	**Academy**	**Enl Comm Prog**	**Total**
No	807	836	270	430	199	2,542
	84.7%	82.9%	86.8%	91.7%	80.2%	85.0%
Yes	146	173	41	39	49	448
	15.3%	17.1%	13.2%	8.3%	19.8%	15.0%
All	953	1,009	311	469	248	2,990
	31.9%	33.7%	10.4%	15.7%	8.3%	100%
Pearson chi2 = 25.387 sig. = 0.000 (with 4 df)						

e. Undergraduate Major

Table 11 provides the distribution of ASTB waivers by undergraduate major. As expected, the greatest percentage of waivers was granted to student-aviators with non-technical undergraduate degrees (9.4%), followed by those with other technical degrees (8.1%) and engineering graduates (5.3%). Since the p-value associated with the chi-squared test for this contingency table is less than 5%, it can be said that whether an individual is granted an ASTB waiver is associated with his or her undergraduate major.

Table 11. Distribution of ASTB Waivers by Undergraduate Major

Waiver	***USMC ASTB Waivers by Undergraduate Major***			
	Engineering	**Other Technical**	**Non-Technical**	**Total**
No	425	488	1,821	2,734
	94.7%	91.9%	90.6%	91.4%
Yes	24	43	189	256
	5.3%	8.1%	9.4%	8.6%
All	449	531	2,010	2,990
	15.0%	17.8%	67.2%	100%
Pearson chi2 = 7.897 sig. = 0.019 (with 2 df)				

Table 12 presents flight school attrition rates by undergraduate major. Considering that students with non-technical undergraduate degrees were granted the greatest percentage of ASTB waivers, it was expected that they would also experience the highest attrition rate. The data support this proposition. Students with non-technical undergraduate degrees experienced the highest rate (16.7%), followed by those with other technical degrees (13.2%). A much smaller percentage (9.6%) of engineering graduates attrited for performance or motivation reasons. The chi-squared test also reveals that academic background is associated with flight school attrition.

Table 12. Flight School Attrition by Undergraduate Major

Attrite	Flight School Attrition by Undergraduate Major			
	Engineering	**Other Technical**	**Non-Technical**	**Total**
No	406	461	1,675	2,542
	90.4%	86.8%	83.3%	85.0%
Yes	43	70	335	448
	9.6%	13.2%	16.7%	15.0%
All	449	531	2,010	2,990
	15.0%	17.8%	67.2%	100%
Pearson chi2 = 16.126 sig. = 0.000 (with 2 df)				

f. Program

Tables 13 and 14 present the distribution of ASTB waivers and flight school attrition rates by student program. Of note, nearly 90% of the students in the sample were pilot-candidates. Interestingly, Table 13 clearly shows that the percentage of NFOs who were granted waivers (16.3%) was much higher than the percentage of student-pilots who were granted waivers (7.6%). Considering that NFOs are granted more waivers, it is not surprising that they also attrite at higher rates, 19% compared with 14.5% for student-pilots.

Table 13. Distribution of ASTB Waivers by Program

Waiver	USMC ASTB Waivers by Program		
	Pilot	**NFO**	**Total**
No	2,447	287	2,734
	92.4%	83.7%	91.4%
Yes	200	56	256
	7.6%	16.3%	8.6%
All	2,647	343	2,990
	88.5%	11.5%	100%
Pearson chi2 = 29.837 sig. = 0.000 (with 1 df)			

Table 14. Flight School Attrition by Program

Attrite	Flight School Attrition by Program		
	Pilot	NFO	Total
No	2,264	278	2,542
	85.5%	81.0%	85.0%
Yes	383	65	448
	14.5%	19.0%	15.0%
All	2,647	343	2,990
	88.5%	11.5%	100%
Pearson chi2 = 4.787 sig. = 0.029 (with 1 df)			

Since the p-values for both tables above are highly significant, the null hypothesis that ASTB waivers and flight school attrition are independent of student program can be rejected.

g. Fiscal Years

Table 15 provides the distribution of ASTB waivers by fiscal year. At first glance, one can see a fair amount of variation in the percentages of waivers granted over this eight-year period. As a reminder, the fiscal year 1999 percentage does not account for waivers granted from October to December of 1998. Regardless, it is interesting that the percentage of waivers granted seems to increase steadily from fiscal year 1999 to 2002. While it is unknown when precisely the Marine Corps implemented the 10% annual cap on waivers, perhaps the decision was made in light of this apparent negative trend. Overall, the chi-squared test reveals that the differences across fiscal years are, in fact, significant.

Considering these differences, it was expected that flight school attrition rates would also vary significantly across the fiscal years. However, as indicated in table 16, the attrition rates are not significantly different. The lowest attrition rate was realized in fiscal year 2003 (12.1%), followed closely by 2004 (12.4%). For the remaining years, the attrition rate fell between 15% and 17%.

Table 15. Distribution of ASTB Waivers by Fiscal Year

Waiver	USMC ASTB Waivers by Fiscal Year Cohort								
	FY99	**FY00**	**FY01**	**FY02**	**FY03**	**FY04**	**FY05**	**FY06**	**Total**
No	240	328	390	306	395	351	383	341	2,734
	93.4%	91.9%	89.2%	84.5%	94.0%	92.9%	93.2%	92.7%	91.4%
Yes	17	29	47	56	25	27	28	27	256
	6.6%	8.1%	10.8%	15.5%	6.0%	7.1%	6.8%	7.3%	8.6%
All	257	357	437	362	420	378	411	368	2,990
	8.6%	11.9%	14.6%	12.1%	14.0%	12.6%	13.7%	12.3%	100%
Pearson chi2 = 33.018 sig. = 0.000 (with 7 df)									

Table 16. Flight School Attrition by Fiscal Year

Attrite	Flight School Attrition by Fiscal Year Cohort								
	FY99	**FY00**	**FY01**	**FY02**	**FY03**	**FY04**	**FY05**	**FY06**	**Total**
No	219	296	366	306	369	331	343	312	2,542
	85.2%	82.9%	83.8%	84.5%	87.9%	87.6%	83.5%	84.8%	85.0%
Yes	38	61	71	56	51	47	68	56	448
	14.8%	17.1%	16.2%	15.5%	12.1%	12.4%	16.5%	15.2%	15.0%
All	257	357	437	362	420	378	411	368	2,990
	8.6%	11.9%	14.6%	12.1%	14.0%	12.6%	13.7%	12.3%	100%
Pearson chi2 = 7.255 sig. = 0.403 (with 7 df)									

D. SUMMARY

This chapter seeks to describe the data used in this research. Data obtained from CNATRA and TFDW were merged to create a dataset consisting of demographic and Naval flight school training data for 2,990 Marine student-aviators who began API between 1 January 1999 and 30 September 2006. The data were used to create a binary dependent variable, “attrite,” that assumes a value of one for those students that were disenrolled from training for academic performance, flight performance, or motivation reasons. Since this study focuses on attrition for these three reasons, 81 students who were disenrolled for other reasons were dropped from the sample.

Various categories of explanatory variables were also created, to include demographics (age, gender, marital status, race/ethnicity), undergraduate degree major, commissioning source, program type (pilot or NFO), and fiscal year cohorts. Contingency tables and chi-squared tests were then used to examine the relationship between ASTB waiver and flight school attrition, and the categories of explanatory variables. When examined separately, the chi-squared tests reveal that the granting of an ASTB waiver to Marine student-aviators is associated with gender, marital status, race/ethnicity, undergraduate degree major, commissioning source, program type, and fiscal year cohort. The tests also reveal that whether a Marine student-aviator attrites from flight school is associated with the same variables, except gender and fiscal-year cohorts. These preliminary results provide support for including these variables in the student-aviator attrition models used in this thesis.

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IV. METHODOLOGY AND RESULTS

A. INTRODUCTION

This thesis uses multivariate regression to test the hypotheses that Marine student-pilots and NFOs with an ASTB minimum score waiver are not significantly more likely to attrite from flight training. The literature review and preliminary data analysis provided the basis for including various regressors or explanatory variables in the statistical models. This thesis also uses the regression results to simulate the effect of changing the Marine Corps current ASTB minimum score waiver policy to allow more than ten percent of aviator candidates to enroll each fiscal year with a test score waiver. The statistical models and regression results are presented first, followed by a description of the simulation methodology and results.

B. STATISTICAL MODELS

Since the dependent variable, “attrite,” can only assume a value of one or zero, the logistic regression model was used. Logistic regression is preferred over the linear probability model (LPM) when the dependent variable is binary because the LPM can result in both negative values and values above one (Stock & Watson, 2003, p. 302). When using logistic regression to predict the probability of a certain outcome, such as the probability of a Marine student-aviator attriting from training, values below zero or above one obviously do not make sense.

Figure 9 provides the logistic regression model where p_i is the probability of attrition, $\left(\frac{p_i}{1-p_i}\right)$ is the odds ratio, $\ln\left(\frac{p_i}{1-p_i}\right)$ is the natural logarithm of the odds ratio (dependent variable), β_0 represents the intercept, $X_1,\ldots,X_k$ represent

the explanatory variables, and $\beta_1, \ldots, \beta_k$ represent the coefficients of the explanatory variables. The odds ratio is simply defined as the probability of an event divided by the probability of the non-event.

$$\boxed{\ln\left(\frac{p_i}{1-p_i}\right) = \beta_o + \beta_1 x_1 + \ldots + \beta_k x_k}$$

Figure 9. Logistic Regression Model

Keller explains that the coefficients (β's) in the logistic regression model are estimated using maximum likelihood estimation (MLE), which results in the logistic regression equation provided in Figure 10 below where $\widehat{\frac{p_i}{1-p_i}}$ is the estimated odds ratio or the probability of attriting divided by the probability of not attriting (p. 685). As the name implies, MLE chooses the parameter values that are most likely in the face of the observed data. The resulting logit coefficients ($b's$) are expressed as effects on log odds and can be difficult to interpret. Therefore, they are often converted to effects on odds by exponentiation, that is, by raising the base of the natural logarithm, e, to the power b.

$$\boxed{\ln\widehat{\left(\frac{p_i}{1-p_i}\right)} = b_0 + b_1 x_1 + \ldots + b_k x_k}$$

Figure 10. Logistic Regression Equation

When interpreting the coefficients, it is said that an odds ratio greater than one means that a one-unit change in the associated explanatory variable increases the odds of the event occurring or that it has a positive effect. Similarly, an odds ratio less than one is interpreted as a negative effect on the odds of the event. Finally, a one-unit change in an explanatory variable with an odds ratio equal to one is said to have no effect.

To test the hypotheses, logisitic regressions were performed on the dependent variable "attrite." While the effects of all explanatory variables are presented, the key variable(s) of interest were either "ASTB_waiver" or the variables representing the separate ASTB waiver score combinations (e.g., 4/5, 5/5, 6/5). It is important to remember that the "ASTB_waiver" variable includes all student-aviators who required a waiver, regardless of the combination of ratings that they achieved on the ASTB.

Considering that weighted raw scores from different ASTB subtests are used to compute the flight aptitude ratings for student-pilots and NFOs, and that significant differences exist in the pilot and NFO training pipelines, separate regressions were run for the student-pilot and NFO samples. Therefore, the first set of regressions examined the effect of ASTB waivers on attrition for Marine student-pilots. The second set of regressions examined the effect of ASTB waivers on attrition for Marine student-NFOs. Ten models were tested in total, five for each hypothesis. The purpose of including different models was to add categories of variables sequentially to observe any changes in the effects and significance of the variables. In the final regression for each model (model 5), the "ASTB_waiver" variable was replaced by the representative ASTB waiver score combinations that were available in the dataset. The base or reference case for the final model was a single, non-Hispanic white male student-aviator with a non-technical undergraduate degree, who accessed via the OCC program, began API during fiscal year 1999, and who was not granted an ASTB waiver. The remainder of this chapter provides the results of this study.

C. REGRESSION RESULTS

The regression results for each model are presented in table format. Each table presents a list of the variables used, their associated odds ratios, and their standard errors. The standard errors appear in parenthesis below the odds ratios and asterisks are used to represent statistical significance at the 1 percent (***), 5 percent (**), and 10 percent (*) levels.

The number of observations, pseudo R^2, and likelihood ratio statistic (χ^2) with associated p-value for each model are also reported at the end of each table. While the pseudo R^2 cannot be interpreted as the R^2 in ordinary least squares regression analysis (i.e., the percentage of variation explained), it can be considered a measure of model fit when comparing models using the same data (UCLA, 2008). Therefore, higher pseudo R^2 values generally indicate a better model fit. Finally, when the p-value for the associated likelihood ratio (χ^2) test is less than 5%, it can be said that strong evidence exists in favor of the alternative hypothesis that "the model fits the data significantly better than the model with the intercept only" (Liao, 1994).

1. Marine Student-Pilot Attrition Model

Table 17 provides the results of the Marine student-pilot attrition model. First, it should be noted that the p-values for the likelihood ratio tests show that each model is statistically significant. In other words, each model predicts the odds of a student-pilot attriting better than the model with no explanatory variables. Second, the pseudo R^2, although small, increases slightly for each model. This suggests that model fit improves as additional categories of control variables are added.

The hypothesis tested for each model was that Marine student-pilots with an ASTB waiver are not significantly more likely to attrite than are students without a waiver. In the first four regressions, the odds ratio for the key explanatory variable, "ASTB_waiver," reflects that waivers have the expected effect on attrition. Since the odds ratio is greater than one, the results suggest that, for otherwise identical Marine student-pilots, having a waiver increases the odds of attriting from flight school for performance or motivation reasons. This effect, however, is insignificant at even the 10% level in each of the first four models. In the final model, where separate waiver test-scores were used in lieu of the "ASTB_waiver" variable, the effect of having a waiver for a score of 4/5 is positive and statistically significant at the 5% level. Thus, the attrition odds for

student-pilots with a waiver for an ASTB score of 4/5 are 1.9 times greater than the odds for otherwise identical student-pilots without waivers. It should be noted that for the final model, too few observations were available to allow for an analysis of the effect on attrition of having ASTB score combinations of 3/6 through 3/9 and 7/5 through 9/5. In fact, the dataset included only one student with a score combination of 3/6 and only three with scores of 7/5. Considering the rarity of certain score combinations, it is not surprising that there were no students in the dataset with scores of 3/7 through 3/9, 8/5 or 9/5.

Table 17 also reveals that the effect of an ASTB waiver on the odds of attrition decreases as a student's score increases from 4/5 to 5/5 and 6/5. This suggests that not all student-pilots with a waiver are equally likely to attrite and that the effect of the waiver is positive only for those with the lowest score combination in the dataset or 4/5. In summary, since the odds ratio for the "ASTB_scores_45" variable in the final model is greater than one and statistically significant, the null hypothesis should be rejected in favor of the alternative. Therefore, one can conclude that Marine student-pilots with a waiver for a test score of 4/5 have significantly higher odds of attriting from flight training for performance or motivation reasons, all else held constant.

The remaining results in Table 17 are mostly as expected and consistent with the findings of earlier studies that have examined the effects of similar explanatory variables on flight school attrition. In each model, the effect of an additional year of age is positive and statistically significant at the 1% level. In the final model, the attrition odds are 1.18 times greater for a student-pilot who is one year older than an otherwise identical student. The effect on attrition of being female is also positive but insignificant in every model. The odds of attrition for student-pilots of races other than white and for Hispanics, however, are statistically significant. For student-pilots of all races and ethnicities, the positive effect on the odds of attriting is greatest for black students who have 3.78 times greater odds, all else being equal. The effect is smaller for Marine student-pilots of other races (2.09) and for Hispanic students (1.69).

Table 17. Marine Student-Pilot Attrition Model Results

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Key Independent Var(s)					
ASTB_waiver	1.158	1.141	1.211	1.177	
	(0.230)	(0.226)	(0.244)	(0.239)	
ASTB_scores_45					1.919
					(0.545)**
ASTB_scores_55					0.896
					(0.286)
ASTB_scores_65					0.501
					(0.313)
Demographics					
age	1.170	1.163	1.178	1.179	1.184
	(0.029)***	(0.029)***	(0.035)***	(0.035)***	(0.036)***
female	1.206	1.199	1.230	1.261	1.270
	(0.356)	(0.357)	(0.367)	(0.379)	(0.382)
married	0.965	0.954	0.998	0.994	0.989
	(0.121)	(0.120)	(0.127)	(0.127)	(0.127)
black	3.468	3.584	3.707	3.777	3.780
	(0.918)***	(0.953)***	(0.993)***	(1.021)***	(1.027)***
other_race	1.949	2.036	2.072	2.090	2.093
	(0.498)***	(0.523)***	(0.534)***	(0.542)***	(0.544)***
hispanic	1.672	1.689	1.762	1.796	1.693
	(0.349)**	(0.354)**	(0.372)***	(0.381)***	(0.365)**
Undergraduate Degree					
eng_deg		0.580	0.633	0.631	0.638
		(0.108)***	(0.121)**	(0.121)**	(0.123)**
other_tech_deg		0.712	0.721	0.726	0.720
		(0.112)**	(0.114)**	(0.116)**	(0.116)**
Commissioning Source					
plc			1.046	1.063	1.069
			(0.145)	(0.149)	(0.151)
nrotc			1.137	1.142	1.182
			(0.250)	(0.253)	(0.262)
enl_comm_progs			0.643	0.653	0.642
			(0.147)*	(0.150)*	(0.148)*
academy			0.703	0.709	0.711
			(0.156)	(0.157)	(0.160)
Fiscal Year Cohorts					
fy00				1.193	1.197
				(0.289)	(0.291)
fy01				0.940	0.942
				(0.223)	(0.224)
fy02				1.007	0.992
				(0.246)	(0.243)
fy03				0.562	0.566
				(0.147)**	(0.148)**
fy04				0.756	0.758
				(0.196)	(0.197)
fy05				1.062	1.066
				(0.256)	(0.258)
fy06				1.006	1.012
				(0.249)	(0.250)
intercept	0.003	0.004	0.004	0.003	0.002
Observations	2647	2647	2647	2647	2643
Pseudo R^2	0.036	0.041	0.045	0.052	0.055
LR χ^2	78.16	99.44	99.20	113.40	119.52
Prob > χ^2	0.000	0.000	0.000	0.000	0.000
Standard errors appear in parenthesis; *significant at 10%; ** 5%; ***10%					
* significant at 10%; ** significant at 5%; *** significant at 1%					
Note: coefficients are expressed as odds ratios (i.e., exponentiated logit coefficients)					

The results in Table 17 also reflect that the undergraduate degree variables are significant and in the expected direction. The attrition odds for student-pilots with engineering and other technical undergraduate degrees are less than one and statistically significant at the 5% level. Therefore, one can conclude that the attrition odds for persons with a technical undergraduate degree are significantly lower than the odds for otherwise identical student-pilots with a non-technical degree.

The results for the commissioning source variables differ considerably from what was expected. Specifically, the attrition odds for those who enrolled via the Service Academies and the NROTC program were expected to be lower than the odds for OCC program participants. As indicated in Table 17, however, the effects of these variables, although insignificant, suggest that while the odds of attriting for Service Academy graduates are lower, NROTC graduates have a greater likelihood of attriting than OCC participants. In addition, those who participated in the Marine Corps' enlisted-to-officer programs were expected to have the highest likelihood of attrition among all student-pilots (refer to Tables 9 and 10). Conversely, when controlling for all other variables the results indicate that the odds of attriting for such student-pilots are only 0.64 times as high as the odds for an otherwise identical student-pilot who participated in the OCC program. It should be noted, however, that this effect is only marginally significant at the 10% level.

Finally, within the fiscal year cohorts category, only the "fiscal year 2003" variable is significant. Therefore, it can be said that the attrition odds for Marine student-pilots that began API during fiscal year 2003 are only 0.57 times as high as the odds for those who began API during fiscal year 1999, other things being equal. Since the percentage of ASTB waivers granted was lowest in fiscal year 2003 (refer to Table 15), perhaps the significance of this variable is simply due to differences in ability among the student cohorts.

2. Predicting Marine Student-Pilot Attrition

Before turning to the Marine student-NFO model results, it is worthwhile to further discuss the magnitude of the ASTB waiver effect on attrition for student-pilots. An obvious question at this point is, "How much more likely is a student-pilot with an ASTB waiver to attrite from flight training?" The short answer is that the likelihood of attrition depends on the individual characteristics of the student-pilot who is being considered. One method that is often used is to illustrate this concept is to compute the difference in predicted probabilities of attrition between two nearly identical student-pilots, one with a waiver and one without. To do this, the odds ratios from the student-pilot model (model 5) are first converted to logit coefficients by taking the natural logarithm of each ratio. The equation is Figure 10 is then used to compute logit scores for hypothetical student-pilots. Next, the logit scores are converted to odds by taking the mathematical constant *e* to the power of the logit. Finally, the odds are converted to probabilities by dividing the odds by one plus the odds. The three formulas used to convert the odds ratios to predicted probabilities are provided below in Figure 11.

$$Logit(p_i) = \ln\left(\widehat{\frac{p_i}{1-p_i}}\right) = b_0 + b_1 x_1 + \ldots + b_k x_k$$
$$odds = e^{b_0 + b_1 x_1 + \ldots + b_k x_k}$$
$$probability = odds / (1 + odds)$$

Figure 11. Formulas to Convert Logit Scores to Probabilities

This methodology was used to examine the difference in the predicted probabilities of attrition for two hypothetical sets of nearly identical student-pilots. The results are presented in Table 18. The first set of students are non-Hispanic white men who earned non-technical undergraduate degrees and enrolled via the NROTC program. They began Aviation Preflight Indoctrination (API) during fiscal year 2002, and at the time, they were both married and 23 years old. The only difference between the two students is that student B achieved an ASTB score of 4/5 and was granted an ASTB waiver. Student B achieved an ASTB score

above the Marine Corps' minimums and was not granted a waiver. The results in Table 18 indicate that student A has a predicted probability of attriting of 12.1% and student B has a predicted probability of 20.9%. According to the model, the difference of 8.8 percentage points is a result of the ASTB waiver effect. In other words, student B is 8.8 percentage points more likely to attrite from flight training for performance or motivation reasons, all else held constant.

Table 18. Predicting Probability of Marine Student-Pilot Attrition

		Set 1		Set 2	
	Coefficient	**Student A**	**Student B**	**Student A**	**Student B**
Intercept	-6.013	1	1	1	1
ASTB_4/5	0.652	0	1	0	1
ASTB_5/5	-0.109	0	0	0	0
ASTB_6/5	-0.690	0	0	0	0
age	0.169	23	23	25	25
female	0.239	0	0	1	1
married	-0.011	1	1	0	0
black	1.330	0	0	1	1
other_race	0.738	0	0	0	0
hispanic	0.527	0	0	0	0
eng_deg	-0.449	0	0	0	0
other_tech_deg	-0.328	0	0	1	1
plc	0.067	0	0	1	1
nrotc	0.167	1	1	0	0
enl_comm_prog	-0.443	0	0	0	0
academy	-0.341	0	0	0	0
fy00	0.180	0	0	0	0
fy01	-0.060	0	0	0	0
fy02	-0.008	1	1	0	0
fy03	-0.569	0	0	0	0
fy04	-0.277	0	0	0	0
fy05	0.064	0	0	0	0
fy06	0.012	0	0	1	1
	Logit	-1.984	-1.332	-0.475	0.177
	Odds	0.138	0.264	0.622	1.193
	Probability	12.1%	20.9%	38.3%	54.4%
	Difference	8.8 PPT		16.1 PPT	

The same logic can be applied to compare the second set of students. They are both non-Hispanic black women who earned a technical undergraduate degree and enrolled via the Platoon Leaders Course. They began API during

fiscal year 2006, and at the time, they were both single and 25 years old. Again, the only difference between the two students is that student B achieved an ASTB score of 4/5 and was granted an ASTB waiver. The results in Table 18 indicate that student A has a predicted probability of attriting of 38.3%, while student B has a predicted probability of 54.4%. Therefore, it can be said that student B is 16.1 percentage points more likely to attrite from flight training.

In summary, although according to the model the odds ratio associated with the “ASTB_scores_4/5” variable (1.92) does not change, the actual magnitude of the effect of having an ASTB waiver for a score combination of 4/5 changes, depending on the individual characteristics of the student-pilot(s) being considered.

3. Marine Student-NFO Attrition Model

Table 19 provides the results of the Marine student-NFO attrition models. Again, the results of each likelihood ratio test indicate that all of the models are statistically significant. In addition, the pseudo R^2 increases as additional control variables are added. It also appears slightly larger than in each corresponding student-pilot model.

The hypothesis tested for each model was that the attrition odds for Marine student-NFOs who are granted an ASTB waiver are not significantly greater than the odds for student-NFOs without a waiver. Overall, the results of the NFO models are noticeably different from the results of the student-pilot models. This was expected, and the results support the rationale for performing regression analysis separately on the student-pilot and NFO samples. While the odds ratio for the key explanatory variable, “ASTB_waiver,” is again positive, the effect is noticeably larger and statistically significant at the 5% level in each of the first four models. In the fourth model, the attrition odds for student-NFOs with an ASTB waiver, regardless of the test-score combination, are 2.6 times greater than the odds for otherwise identical student-NFOs without a waiver. In the final model, the attrition odds for student-NFOs with an ASTB score of 4/5 are 3.1

times greater than the odds for student-NFOs without a waiver, all else held constant. This effect is also significant, albeit at only the 10% level. Interestingly, while the effect of ASTB waivers on the odds of attriting also decreases as the waiver score combinations increase from 4/5 to 6/5, the attrition odds remain substantially greater than one. This suggests that, while not all student-NFOs with a waiver have equal odds of attrition, they are more likely to attrite than otherwise identical student-NFOs without a test-score waiver. In summary, the null hypothesis should be rejected in favor of the alternative. One can conclude that holding all else equal, the attrition odds for Marine student-NFOs with an ASTB waiver are significantly higher than for those who meet or exceed the Marine Corps' cutoff scores.

Only three of the remaining control variables in the final model are statistically significant. In each model, the gender effect is negative but insignificant at the 10% level. The effect of being married is positive, but is also statistically insignificant. Furthermore, the effect of an additional year of age is positive, as it was in each pilot model and statistically significant at the 1% level. According to the final model, the attrition odds are 1.2 times greater for student-NFOs who are one year older than otherwise identical student-NFOs, all else being equal.

Table 18 also shows that the effects of race and ethnicity are positive as in the student-pilot models. Holding all else constant, the attrition odds for student-NFOs of "other" races and for Hispanics are significantly higher than the odds for non-Hispanic white students. The effect is also positive for black student-NFOs, but insignificant in every model. This insignificance is likely due to the fact that there were only ten black student-NFOs in the sample, three of which attrited.

Table 19. Marine Student-NFO Attrition Model Results

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Key Independent Var(s)					
ASTB_waiver	2.118	2.051	2.106	2.596	
	(0.760)**	(0.742)**	(0.766)**	(1.030)**	
ASTB_scores_45					3.091
					(1.962)*
ASTB_scores_55					2.289
					(1.249)
ASTB_scores_65					2.616
					(2.244)
Demographics					
age	1.209	1.198	1.210	1.215	1.215
	(0.076)***	(0.076)***	(0.083)***	(0.086)***	(0.087)***
female	0.534	0.560	0.586	0.464	0.451
	(0.355)	(0.375)	(0.393)	(0.328)	(0.322)
married	1.066	1.068	1.091	1.320	1.317
	(0.394)	(0.395)	(0.415)	(0.517)	(0.518)
black	1.514	1.708	1.728	1.712	1.589
	(1.129)	(1.292)	(1.313)	(1.390)	(1.346)
other_race	2.256	2.276	2.237	2.642	2.589
	(1.148)	(1.159)	(1.147)	(1.406)*	(1.391)*
hispanic	2.118	2.252	2.399	2.416	2.380
	(0.904)*	(0.981)*	(1.068)**	(1.160)*	(1.149)*
Undergraduate Degree					
eng_deg		0.529	0.562	0.528	0.525
		(0.278)	(0.304)	(0.290)	(0.288)
other_tech_deg		1.157	1.227	1.310	1.320
		(0.436)	(0.468)	(0.528)	(0.536)
Commissioning Source					
plc			1.389	1.401	1.392
			(0.544)	(0.596)	(0.599)
nrotc			1.035	1.003	1.000
			(0.564)	(0.582)	(0.581)
enl_comm_progs			0.780	0.877	0.876
			(0.350)	(0.421)	(0.422)
academy			0.659	0.743	0.774
			(0.388)	(0.456)	(0.481)
Fiscal Year Cohorts					
fy00				0.789	0.797
				(0.641)	(0.657)
fy01				3.316	3.271
				(2.527)	(2.493)
fy02				0.258	0.263
				(0.262)	(0.268)
fy03				2.486	2.486
				(1.789)	(1.790)
fy04				2.029	2.037
				(1.519)	(1.526)
fy05				3.179	3.222
				(2.308)	(2.344)
fy06				1.517	1.543
				(1.174)	(1.196)
intercept	0.001	0.002	0.001	0.001	0.001
Observations	343	343	343	343	343
Pseudo R^2	0.085	0.091	0.100	0.155	0.156
LR χ^2	28.27	30.31	32.93	51.69	51.83
Prob > χ^2	0.000	0.000	0.002	0.000	0.000
Standard errors appear in parenthesis; * significant at 10%; ** 5%; *** 1%					
Note: coefficients are expressed as odds ratios (i.e., exponentiated logit coefficients)					

The remaining explanatory variables in Table 18 are statistically insignificant. While the effect of having an engineering degree is negative as expected, the odds ratios for the "other technical degree" variable are inexplicably positive. The results for the commissioning source variables are also similar to those in the student-pilot models. Although statistically insignificant, the attrition odds for Service Academy graduates and enlisted-to-officer program participants are lower than those for OCC participants, all else being equal.

4. Predicting Marine Student-NFO Attrition

Before concluding the discussion of the student-NFO attrition model, it is worthwhile to compute the difference in predicted probabilities of attrition for two sets of nearly identical Marine student-NFOs. Again, the purpose is to illustrate how the magnitude of the ASTB waiver effect depends on the characteristics of the student-NFOs who are being examined.

Table 20 provides the differences in the predicted probabilities of attrition for two sets of hypothetical and nearly identical student-NFOs. The students in the first set are Hispanic men who earned a non-technical undergraduate degree and enrolled via one of the Marine Corps' enlisted-to-officer programs. They began API during fiscal year 2006, and at the time, they were both married and 28 years old. The only difference between student A and B is that student B achieved an ASTB score of 4/5 and was granted an ASTB waiver. Student A achieved the Marine Corps' minimum ASTB scores and was not granted a waiver. As shown in Table 20, student A has a predicted probability of attriting of 35.6% and student B has a predicted probability of 63.1%. According to the model, therefore, the difference of 27.5 percentage points is a result of having an ASTB waiver for a score combination of 4/5. In other words, student B is 27.5 percentage points more likely to attrite from flight training for performance or motivation reasons, all else being equal.

The second set of students are both non-Hispanic black women who earned an engineering degree from the United States Naval Academy. They began API during fiscal year 2005, and at the time, they were both single and 22 years old. Again, the only difference between students A and B is that student B achieved an ASTB score of 4/5 and was granted an ASTB waiver. As shown in Table 20, student A has a predicted probability of attriting of 3.7% and student B has a predicted probability of 10.5%. According to the model, the difference of 6.8 percentage points is a result of the ASTB waiver effect. In other words, student B is 6.8 percentage points more likely to attrite from flight training for performance or motivation reasons.

Table 20. Predicting Probability of Marine Student-NFO Attrition

		Set 1		Set 2	
	Coefficient	**Student A**	**Student B**	**Student A**	**Student B**
Intercept	-7.501	1	1	1	1
ASTB_4/5	1.128	0	1	0	1
ASTB_5/5	0.828	0	0	0	0
ASTB_6/5	0.962	0	0	0	0
age	0.195	28	28	22	22
female	-0.796	0	0	1	1
married	0.275	1	1	0	0
black	0.463	0	0	1	1
other_race	0.951	0	0	0	0
hispanic	0.867	1	1	0	0
eng_deg	-0.644	0	0	1	1
other_tech_deg	0.278	0	0	0	0
plc	0.331	0	0	0	0
nrotc	0.000	0	0	0	0
enl_comm_prog	-0.133	1	1	0	0
academy	-0.256	0	0	1	1
fy00	-0.227	0	0	0	0
fy01	1.185	0	0	0	0
fy02	-1.335	0	0	0	0
fy03	0.911	0	0	0	0
fy04	0.712	0	0	0	0
fy05	1.170	0	0	1	1
fy06	0.434	1	1	0	0
	Logit	-0.593	0.535	-3.271	-2.142
	Odds	0.552	1.708	0.038	0.117
	Probability	35.6%	63.1%	3.7%	10.5%
	Difference	27.5 PPT		6.8 PPT	

D. SIMULATION METHODOLOGY

This thesis uses the results from the final student-pilot and NFO attrition models to simulate the effect on flight school attrition of increasing the Marine Corps' current ASTB waiver cap. The models were first used to predict the probability of attrition for each student in the sample. A random sample of student-pilots and NFOs, with and without waivers, was then drawn from the 2,990 students in the dataset. The sample was constrained to include 420 student-pilots and 35 NFOs, the exact numbers provided for in the Marine Corps' fiscal year 2009 accession plan. The ratios of student-pilots and NFOs with ASTB waivers in the sample were also constrained to equal the proportions provided for in the dataset, or 7.6% for student-pilots and 16.3% for NFOs when the waiver rate is approximately 8.6% (see Table 13). The attrition rate was then determined by dividing the sum of the predicted probabilities of attrition for the simulated student sample by the total accession goal of 455 student-aviators. This process was simulated 1,000 times for samples in which no waivers were granted and for samples with the ASTB waiver rate set at the 10%, 12.5%, and 15% levels. Since separate attrition models were used to predict probabilities of attrition, this process was also simulated separately for student-pilots and NFOs. The differences between the mean attrition rates without waivers and at the different waiver levels were then examined. These differences were used to infer the effect on flight school attrition for performance and motivation reasons of changing the Marine Corps' current ASTB minimum score waiver policy to allow more than ten percent of aviator candidates to access each fiscal year with a test-score waiver.

E. SIMULATION RESULTS

The student-pilot simulation results in Table 21 reveal that the mean attrition rate remains nearly constant as the ASTB waiver rate is increased. In fact, the mean attrition rate for the simulation in which no waivers were granted is only 0.6 percentage points lower than for the simulation in which the waiver rate

was set at 15%. As a reminder, since the statistical models were only used to predict attrition for performance or motivation reasons, the simulated attrition rates do not account for student attrition for any other reason.

Considering the results of the student-pilot attrition model (Table 17), these outcomes are as expected. According to the final student-pilot model, the ASTB waiver effect is only positive and statistically significant for those with ASTB score combinations of 4/5. Although students are also granted waivers for score combinations above 4/5 (e.g., 5/5 and 6/5), the pilot model results indicate that the waiver effect for those scores is negative. If the Marine Corps were to grant more waivers, they would be given to aviator candidates with varying ASTB scores. Perhaps the negative effect on attrition of having more student-pilots with waivers for score combinations of 5/5 and 6/5 offsets the positive effect on attrition of having additional students with waivers for score combinations of 4/5.

Table 21. Simulated Marine Student-Pilot Attrition Rates

Descriptive Statistics	No Waivers	10%	12.5%	15%
Mean	0.141	0.145	0.146	0.147
Standard Error	0.000	0.000	0.000	0.000
Median	0.142	0.145	0.146	0.147
Standard Deviation	0.004	0.004	0.004	0.004
Range	0.024	0.025	0.025	0.030
Minimum	0.129	0.134	0.134	0.133
Maximum	0.153	0.158	0.159	0.163
Sum	141.466	145.129	146.152	147.081
Count	1000	1000	1000	1000

The student-NFO simulation results appear in Table 22. The results indicate that the mean attrition rate increases as a greater percentage of waivers are granted but at a decreasing rate. While the attrition rate increases by 2.3 percentage points when the waiver rate is increased to 10%, it increases by only 0.7 percentage points as the waiver rate is changed to 12.5%.

According to the final student-NFO model (Table 19), the ASTB waiver effect is positive for all waiver score combinations, albeit only statistically significant for the "ASTB_waiver_4/5" variable. Therefore, the effect on flight school attrition of granting more ASTB waivers to student-NFOs would be positive, regardless of the number of different waiver score combinations. However, the Marine Corps' recruits a small number of NFOs each year relative to the number of pilots. If the Marine Corps were to access 35 NFOs, a 2.3 percentage point increase in the NFO attrition rate would result in one additional student attriter. Considering that CNATRA estimated the cost of training a Marine student-NFO in 2007 at $298,310.58, the Marine Corps may consider even one additional NFO attriter to be significant.

Table 22. Simulated Marine Student-NFO Attrition Rates

Descriptive Statistics	**No Waivers**	**10%**	**12.5%**	**15%**
Mean	0.170	0.193	0.200	0.204
Standard Error	0.001	0.001	0.001	0.001
Median	0.170	0.191	0.199	0.202
Standard Deviation	0.023	0.026	0.026	0.026
Range	0.148	0.156	0.166	0.172
Minimum	0.111	0.126	0.125	0.124
Maximum	0.258	0.282	0.291	0.296
Sum	170.438	193.171	199.934	203.759
Count	1000	1000	1000	1000

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V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

Each year, the Marine Corps enrolls hundreds of student-aviator candidates from various commission sources in its pilot and Naval Flight Officer (NFO) programs. The Aviation Selection Test Battery (ASTB) is one of the key selection instruments that is used to screen out candidates who are less likely to succeed in Naval flight training. The ASTB, which has evolved considerably from the early aviation selection tests of the 1940s, has been validated to predict student-aviator performance and attrition. Current Marine Corps policy states that aviator candidates must achieve an Academic Qualifications Rating (AQR) and Flight Aptitude Rating (FAR) on the ASTB of at least 4/6, respectively, in order to be selected into the aviation training pipeline. The Marine Corps also allows one-point waivers in either rating, but not both, for no more than 10% of its aviator accessions each fiscal year.

Establishing minimum or “cutoff” scores on a selection test is influenced by the size of the population eligible for testing, the desired selection ratio, and testing and selection costs. While low cutoff scores can provide a higher selection rate and lower testing and selection costs, they can also result in higher attrition. Conversely, while high cutoff scores may lower attrition costs, the result can create a more challenging and costly situation for an organization to achieve its desired selection ratio. Therefore, it follows that if the Marine Corps’ ASTB cutoff scores are too high, and Marine student-aviators who are granted a waiver are not significantly more likely to attrite from training than those without a waiver, the Marine Corps may be unnecessarily incurring additional testing and selection costs by excluding otherwise qualified aviator candidates from training.

This study has examined whether Marine student-aviators who are granted an ASTB waiver are significantly more likely to attrite from flight training than are those without a waiver. It has also analyzed the effect on student-aviator attrition of increasing the Marine Corps' policy to allow more than ten percent of aviators to enroll each fiscal year with a test-score waiver.

For Marine student-pilots, the results indicate that the attrition likelihood for persons with a waiver for an ASTB score of 4/5 are 1.9 times greater than the odds for otherwise identical student-pilots without a waiver. For Marine student-NFOs, the results show that the attrition likelihood for persons with a waiver, regardless of their ASTB test-score, are 2.6 times greater than the odds for otherwise identical student-NFOs without a waiver.

The student-pilot simulation results revealed that the mean attrition rate remained nearly constant as the ASTB waiver rate was increased from zero to 15%. The student-NFO simulation results revealed that the mean attrition rate increases, albeit at a decreasing rate, as a greater percentage of waivers are granted.

B. CONCLUSIONS

Although it is difficult to forecast student-aviator attrition, the results of this study suggest that the ASTB remains a valid predictor. Holding all else constant, persons who achieve test-scores below the Marine Corps' cutoff are significantly more likely to attrite from training. As expected, the likelihood of attrition for persons with a waiver also decreases as test-scores increase from 4/5 to 5/5 and 6/5. The effect of other possible waiver score combinations (i.e., 3/6 to 3/9 and 7/5 to 9/5) are rarely observed and, therefore, could not be examined.

The results show that the ASTB waiver effect is much greater for student-NFOs than for student-pilots. Additionally, student-NFOs who are granted a waiver, regardless of their ASTB score, are significantly more likely to attrite. Conversely, only student-pilots with the lowest waiverable score in this study

(i.e., 4/5) appear significantly more likely to attrite. This is a matter of some concern. Historically, NFO candidates have been granted a greater percentage of test-score waivers and they have experienced higher attrition rates than student-pilots. The obvious conclusion here is that the Marine Corps has incurred additional attrition costs by granting more waivers to NFO candidates. The obvious question here is whether these additional attrition costs are worth the benefits of granting more waivers.

The larger issue is whether the Marine Corps can achieve its aviator recruiting mission without granting ASTB waivers. According to Dean (1996), the Marine Corps was selecting enough candidates at the 4/6 cutoff in the mid-1990s that test-score waivers only negated the cost-saving benefits provided by the ASTB. Assuming that the Marine Corps had to offer test-score waivers in recent years because the pool of qualified applicants at the 4/6 cutoff was insufficient, the results of this study suggest that the Corps has reduced attrition and re-training costs by achieving its goals under the 10% waiver cap. If the Marine Corps must continue to grant waivers to meet its recruiting goals, attrition costs may be reduced by limiting the number of waivers for student-NFOs and by granting waivers for student-pilots who achieve a waiverable ASTB test-score greater than 4/5.

The present study shows that the Marine Corps is granting a larger percentage of waivers to women and minority candidates. The reasons for this are unknown, but it appears that the waiver process assists in identifying otherwise qualified applicants. The analysis conducted here indicates that women candidates perform as well as men, but that minority students are significantly more likely to attrite, all else being equal. The underlying reasons for these differences in attrition are a good topic for further research.

The results of this study show that the magnitude of the ASTB waiver effect corresponds with certain student characteristics. Most notably, students with an engineering or other technical degree and those who enroll through one of the Marine Corps' enlisted-to-officer programs appear to have a lower

likelihood of attrition, holding all else constant. Since all student-aviators with an ASTB waiver are not equally likely to attrite, perhaps the Marine Corps should look toward further refinements in screening that can reduce the likelihood of attrition by students with high risk characteristics. At the same time, those with characteristics that signal a lower risk of attrition, such as graduates of an engineering or technical program, can be targeted for recruitment.

The anticipated release of a new version of the ASTB in fiscal year 2010 offers great promise. The revised exam is expected to include new sub-tests that will potentially improve the validity of the ASTB as a predictor of student-aviator performance and attrition. In the meantime, the Marine Corps may benefit by continuing to limit the number of ASTB waivers that it grants and by studying other factors that may counterbalance the positive effect of test-score waivers on student-aviator attrition.

C. RECOMMENDATIONS

1. Maintain Current ASTB Minimum Scores Waiver Policy

Considering the results of the student-pilot and NFO attrition models used in this study, it is the researcher’s opinion that the Marine Corps should maintain its current ASTB cutoff scores and waiver policy. Student-NFOs who are granted an ASTB waiver, regardless of their test score combinations, and student-pilots who are granted waivers for score combinations of 4/5 are more likely to attrite from flight training for performance or motivation reasons. Assuming that waivers are limited to the number necessary to achieve accession goals, the Marine Corps will likely reduce attrition by minimizing the number of waivers that it grants.

2. Further Research

This thesis offers three recommendations for further research. First, the models used in this study do not account for student attrition during Introductory

Flight Screening (IFS), the preliminary training program designed to screen out candidates who lack the motivation or ability to successfully complete follow-on training. The Marine Corps may be interested in determining if the results presented here change significantly when attrition during IFS is included in the statistical models. Second, the Marine Corps may benefit from a study that further examines the effects of the student characteristics included in this research. Such a study could prove valuable in screening aviator applicants who require a waiver, thereby reducing flight school attrition rates. Finally, the Marine Corps may consider incorporating the results of this research into a thorough policy analysis. The policy analysis could examine the effects of changing the current ASTB waiver policy on other important factors, such as recruiting costs, flight training costs, and minority representation.

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APPENDIX A. DEGREES REPRESENTING UNDERGRADUATE MAJOR INDICATOR VARIABLES

ENGINEERING		
Aeronautical Engineering	Chemical Engineering	Industrial Engineering
Aerospace Engineering	Civil Engineering	Marine Engineering
Agricultural and Bio Engineering	Computer Engineering	Materials Engineering Science
Astronautical Engineering	Electrical Engineering	Mechanical Engineering
Aviation Engineering	Environmental Engineering	Mining Engineering
Aviation Engineering	Facilities Engineering	Ocean Engineering
Avionics Engineering	General Engineering	Systems Engineering
Biomedical Engineering	Geological Engineering	Technology Engineering

OTHER TECHNICAL		
Aeronautical Science	Biological Sciences	Mathematics
Aeronautical Technology	Biomedical Science	Meteorology
Aerospace Science	Building Science	Natural Science
Aerospace Studies	Chemistry	Naval Architecture
Aerospace Technology	Computer Science	Neuroscience
Aircraft Maintenance	Electronics	Oceanic Science
Airway Science	Electronics Technology	Oceanography
Applied Science	Engineering Science	Operations Research
Architecture	Environmental Science	Physical Science
Astronomy	General Science	Physics
Aviation	Geology	Professional Aeronautics
Aviation Science	Geosciences	Science and Technology
Aviation Systems	Marine Science	
Aviation Technology	Maritime Ops and Technology	

NON-TECHNICAL		
Accounting	Forestry	National Security Studies
Aerospace Administration	General Studies	Natural Resources
Agriculture	Geography	Nursing
Agronomy	Graphic Design	Philosophy
Anthropology	Health/Nutritional Science	Physical Education
Archeology	History	Political Science/Govt
Aviation Business Admin	Horticulture	Printing Management
Aviation Management	Human Factors	Psychology
Broadcasting	Human Resources	Public Relations
Building Construction	Humanities	Range Science
Business/Management	Industrial Design/Studies	Real Estate
Communications	Information Sys/Mgmt	Recreation Management
Computer Graphics Design	Intelligence	Rehabilitation
Construction Management	Interdisciplinary Studies	Religious Studies
Construction Science	International Relations/Studies	Safety Science
Consumer Affairs	Journalism	Security Studies
Criminal Justice	Kinesiology	Social Science/Studies
Cultural Studies	Labor Relations	Sociology
Digital Imaging	Landscape Architecture	Speech
Economics	Law	Sports Management
Education	Liberal Arts	Sports Medicine
English	Liberal Science	Systems Admin/Mgmt
Environmental Studies	Linguistics	Technology Education/Mgmt
Exercise Science	Literature	Theater/Arts
Film	Logistics	Votech Education
Finance	Marine Transportation	Wildlife Mgmt/Science
Foreign Affairs	Marketing	
Foreign Language	Military Studies	

APPENDIX B. SUMMARY STATISTICS

VARIABLE	OBS	MEAN	STD. DEV.	MIN	MAX
Dependent					
attrite	2990	0.150	0.357	0	1
Key Explanatory					
ASTB_waiver	2990	0.086	0.280	0	1
Demographics					
age	2990	25.344	2.247	20.931	35.261
female	2990	0.039	0.193	0	1
married	2990	0.308	0.462	0	1
white	2990	0.872	0.334	0	1
black	2990	0.026	0.159	0	1
other_race	2990	0.038	0.192	0	1
hispanic	2990	0.064	0.244	0	1
Undergraduate Degree					
eng_deg	2990	0.150	0.357	0	1
other_tech_deg	2990	0.178	0.382	0	1
non_tech_deg	2990	0.672	0.469	0	1
Commissioning Source					
occ	2990	0.337	0.473	0	1
plc	2990	0.319	0.466	0	1
nrotc	2990	0.104	0.305	0	1
enl_comm_progs	2990	0.083	0.276	0	1
academy	2990	0.157	0.364	0	1
Program					
nfo	2990	0.115	0.319	0	1
Fiscal Year Cohorts					
fy99	2990	0.086	0.280	0	1
fy00	2990	0.119	0.324	0	1
fy01	2990	0.146	0.353	0	1
fy02	2990	0.121	0.326	0	1
fy03	2990	0.140	0.348	0	1
fy04	2990	0.126	0.332	0	1
fy05	2990	0.137	0.344	0	1
fy06	2990	0.123	0.329	0	1

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